New Scientist

WEEKLY 26 July 2025

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IS IT TIME FOR THE WORLD TO AIM FOR 1.7°C?

HOW HUMAN EGGS STAY FRESH FOR SO LONG

A BACKDOOR TO REALITY

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ORIGINS OF BURIAL

What the earliest funerals reveal about ancient hominin minds

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The Bel Canto: what all the noise is about

On its launch day, the C1 Bel Canto sold out immediately. A second version, released days later, went in under three hours. (Or just three chimes.) Never before has a watchmaker launched a 'Sonnerie au Passage' to such a clamour. Never before has a 60-minute chiming mechanism (a 60-part adaptation of an already-modified movement) resembled a songbird. Cometh the hour, cometh the hammer (the bird's tail) striking the titanium case – resulting in a crystal-clear, 'D' note. Since launching in November 2022, it's somewhat appropriately attracted a number of industry gongs. And a cacophany of ringing endorsements, like Hodinkee's "Shockingly affordable". Can we look forward to hearing from you?

Do your research

Christopher Ward

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How the brain invents your reality

Join Daniel Yon on 18 October at Excel London as he delves into how our brains interpret the world around us, from physical objects to social interactions. Drawing on the latest research in neuroscience and psychology, he reveals that our brains, much like scientists, use past experiences to build models and predict reality.

newscientist.com/nslive

Tour

The geology of the Pyrenees: Spain

Discover the dramatic beauty and rich heritage of the Spanish Pyrenees on a journey that blends vibrant culture, world-class geology and unforgettable landscapes. Wander medieval villages, step inside majestic cathedrals and walk a stretch of the legendary Camino de Santiago. This seven-day tour starts on 14 September and costs £4300.

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Podcast

The world, the universe and us

This week, the team discusses the controversial proposal that we should abandon 1.5°C as the limit for global warming and instead aim for 1.7°C. Discover the earliest evidence for plate tectonics on Earth. Plus, find out how transplants of modified gut bacteria may help fine-tune our microbiomes to help prevent or even treat disease.

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LEROY JULIEN/ALAMY

Soar into the mountains Enjoy the geology of the Pyrenees

WILL SARDINSKY

Hail hunters Chasing hailstorms in the US Great Plains

Video

Storm chasers

Dozens of meteorologists have undertaken the largest-ever study of extreme hail across the US Great Plains. *New Scientist* environment reporter James Dinneen hitched a ride inside a fortified truck called the Hail Hunter to get an inside view of the campaign during one of the most extreme hailstorms to hit the Texas panhandle.

youtube.com/newscientist

Newsletter

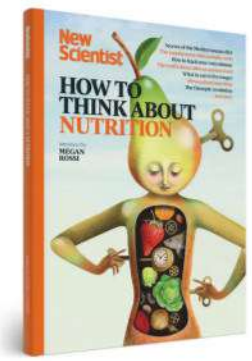
Health Check

Mutations in mitochondria can lead to debilitating health conditions. The birth of eight healthy babies using a "three-parent baby" technique, in which genetic material from the mother and father is combined with mitochondria from a donor egg, shows the method has promise for prevention.

newscientist.com/healthcheck

Podcast

"If we aim for 2°C of warming, we are likely to exceed it"



How to think...

In the third issue of our new *How to Think About* series, we explore cutting edge nutritional science with the world's experts as our guides. Whether you are looking to lose weight, live longer or just feel better, you'll find everything you need to nourish your future health.

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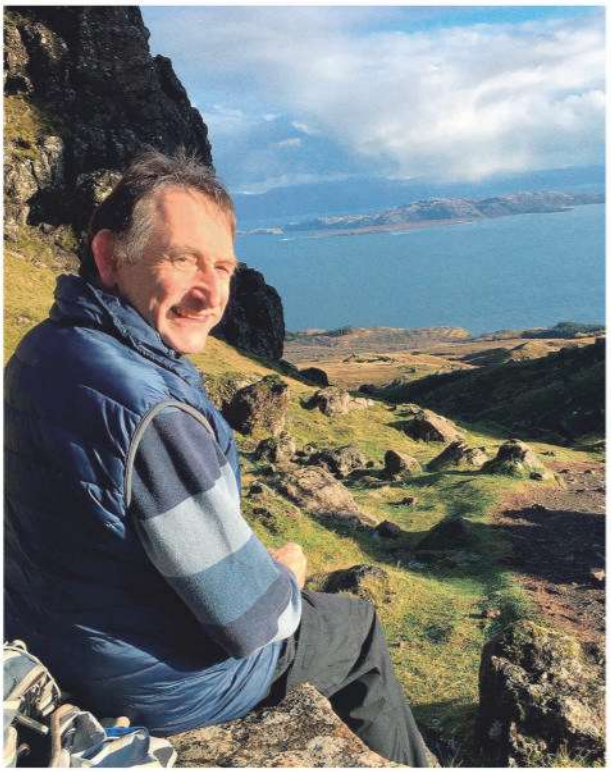
People can be a happy place. **Jo's** four children are his. His world is never bigger than with them. Out on a hike. Everyone together. It's when Perthshire is at its most beautiful.

But his favourite bit? When the walk is finally over and the whole family sits down for a proper cup of tea and ever-so-slightly overdone fruit cake.

It's what made his late wife, Sue, happiest. The brood of kids all around her. Stomachs and hearts full. And it's the part he now cherishes most.

That's why he left a gift to Cancer Research UK in his Will.



So more famillies can have more time together.

For **Daniel**, it's been twelve more years with his loved ones - and counting. His Hodgkin Lymphoma diagnosis at just twenty-three was a huge shock. He felt lost, but never alone. His boyfriend Adam holding his hand every step of the way.

After four rounds of chemotherapy and two weeks of radiotherapy, which CRUK pioneered, he was given the all clear.

In 2023, he and Adam celebrate their first anniversary as husband and hubby. Cherishing every anniversary since.

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Dead and buried

If ancient humans had their own funeral rituals, what does that mean for us?

FROM a young age, the inevitability and finality of death becomes a shaping force in our lives. Indeed, it could be said that our ability to recognise our eventual demise and the grief that comes with losing those close to us are core elements of what it means to be human. They have also led to symbolic practices that have deep roots in human culture.

We have long assumed that *Homo sapiens* was the only human species to have gained an awareness of the mortality of living things. But as we report on page 38, archaeologists are eager to question the idea that a deep and emotional response to death is our sole preserve.

The most challenging of their claims is that ancient humans who were very unlike us developed death rituals. But evidence is mounting that *Homo naledi*, an ancient human from southern Africa with a brain one-third the size of your own, buried its dead at least 245,000 years ago. Exactly why these small-brained humans may have felt compelled to develop a culture of death is unclear, but one intriguing – if speculative – idea is that they did so to help youngsters come to terms with the loss of a group member.

> "Archaeologists are questioning whether a deep response to death is our sole preserve"

Much controversy surrounds the claim that *H. naledi* buried its dead, largely concerning the quality of the evidence. But since the mid-20th century, researchers have been busily narrowing the behavioural gap between our species and others, spearheaded by research showing that many animals have emotionally rich lives. Some even develop their own rituals when confronted with the death of community members. Throw in evidence that our ancestors were developing their own artistic culture at least 500,000 years ago and it is easier to accept that *H. naledi* was capable of developing its own burial traditions.

The provocative image of a grief-stricken *H. naledi* helping its young deal with loss forces as much of a rethinking about these ancient relatives as it does a reckoning of what it means to be human – and whether we are as special as we like to think. ▮

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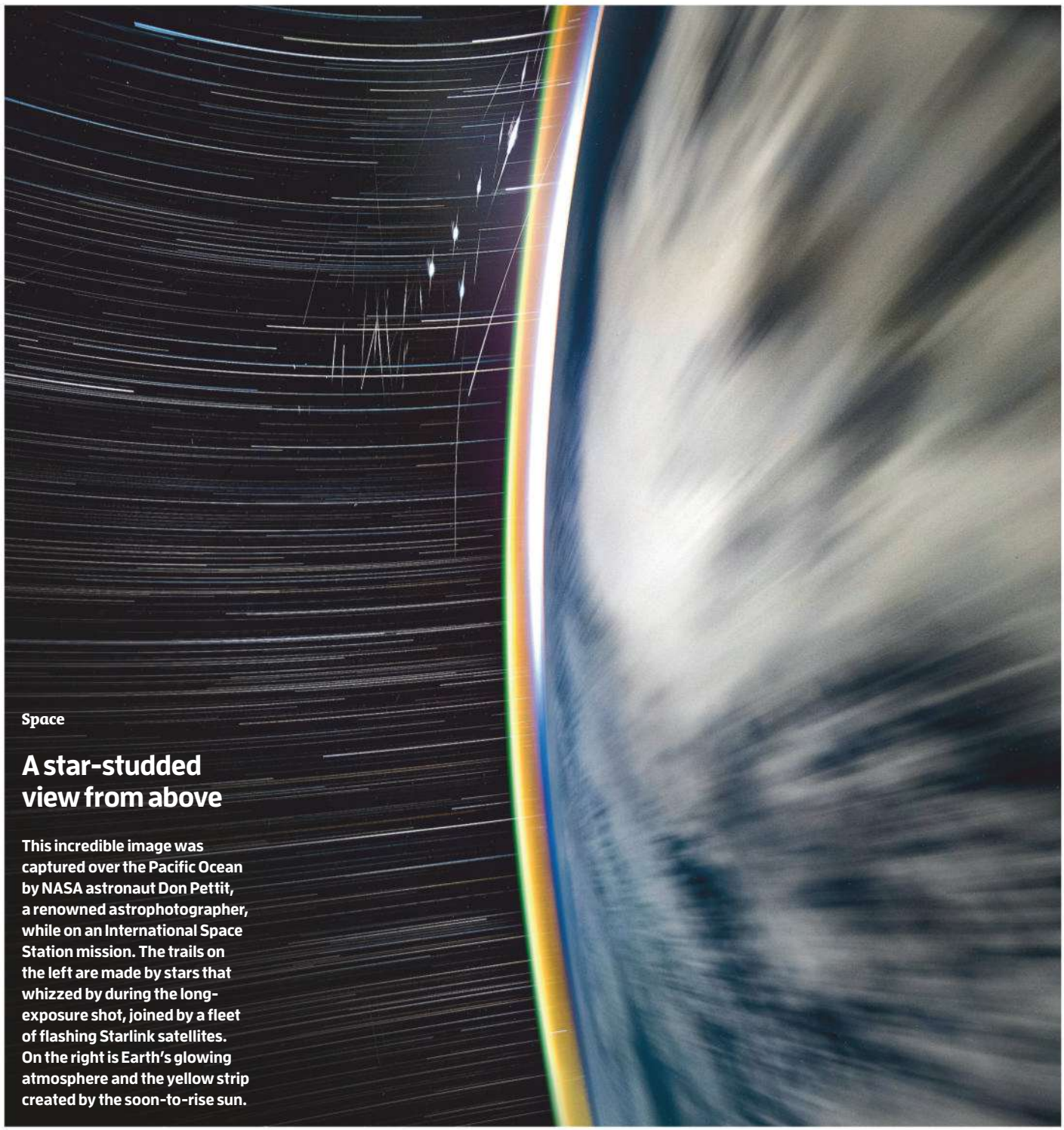


Space

A star-studded view from above

This incredible image was captured over the Pacific Ocean by NASA astronaut Don Pettit, a renowned astrophotographer, while on an International Space Station mission. The trails on the left are made by stars that whizzed by during the long-exposure shot, joined by a fleet of flashing Starlink satellites. On the right is Earth's glowing atmosphere and the yellow strip created by the soon-to-rise sun.

DON PETTIT/NASA

Climate change

Is it time to aim for 1.7°C?

With the world on the cusp of passing 1.5°C of warming, scientists are turning their attention to defining a new limit – but not everyone agrees that we should, says **Madeleine Cuff**

IF YOU told a child to stay "well away" from a cliff edge, how close to the edge could they creep before you started shouting for them to turn back? That is the question puzzling climate scientists right now, as it looks almost certain that we will breach the global commitment to limiting warming to no more than 1.5°C above pre-industrial levels. As we enter the danger zone, what comes next?

"Governments have set themselves 1.5°C targets. But what those mean in a world where we're already past 1.5°C is harder and harder to understand," says Robin Lamboll at Imperial College London. "I think it would be very helpful if people started talking much more concisely and concretely about the actual goals they have in mind."

Those national targets are derived from the international Paris Agreement, which was signed in 2015 and is a vague starting point for defining climate limits. The text formally commits countries to "pursuing efforts" to limit warming to 1.5°C and to holding any temperature increase to "well below" 2°C. But how low is "well below"?

"The wording of the long-term temperature goal of the Paris Agreement is both a solution and a challenge," says Joeri Rogelj, also at Imperial College London. "The solution is that this was the wording that countries could agree to. The challenge is that it leaves room for interpretation."

Rogelj fears that unless the meaning of "well below" 2°C is clarified – and swiftly – there is a risk that the world simply takes 2°C as the new line in the sand. The trouble is, many scenarios for achieving 2°C provide only a 50 per cent chance of success, meaning that aiming for this line could still see us vastly overshooting it.

ANTONIO MASIELLO/GETTY IMAGES

Temperatures in Rome , Italy, hit 40°C earlier this month

1.5°C
Target to limit warming by in the Paris Agreement

1.9°C
Warming prediction by 2100 if every country fulfils all of its climate promises

2.6°C
Warming predicted by 2100 if we follow current policies

To address this, Rogelj and Lamboll point out that international agreements are generally required to use a normal understanding of words. So, if the Paris Agreement promises to keep temperatures well below 2°C, the pair argue that most people wouldn't expect a significant risk of overshoot to be compliant with that promise.

Yet as things stand, two model scenarios might both claim to limit warming to below 2°C, but one might offer just a 66 per cent chance of staying below the limit, while the other offers a 90 per cent chance. "People are not very good at dealing with probabilities," says Lamboll. "A 66 per cent chance and a 90 per cent chance are incredibly different things."

This uncertainty arises from different assumptions underlying the scenarios, with those requiring a stricter control on emissions having a better chance of staying below 2°C. The pair argue that peak temperature – the most the world is likely to warm before any mitigation measures kick in to bring temperatures down – better captures the differences between scenarios and so provides a clearer boundary for climate goals.

In unpublished work, Rogelj and Lamboll assessed four 2°C climate-model scenarios, calculating for each the median peak temperature required to stay below 2°C with a 66 per cent, 83 per cent and 90 per cent chance. For example, one scenario shows that for a 66 per cent chance of staying below the limit, temperatures should peak at about 1.83°C, but for a 90 per cent chance, they would need to peak at 1.54°C.

Looking across all of the models, the pair conclude that, to offer the world an 83 per cent chance of remaining below 2°C of warming – a fair representation, they say, of the promise to remain "well below" the threshold – the median temperature can't peak beyond

1.63 to 1.67°C, the range given by all of the models.

Other researchers are coming to the same conclusion. Gottfried Kirchengast and Moritz Pichler, both at the University of Graz in Austria, recently proposed 1.7°C as the peak temperature limit to keep us "well below 2°C", because it is in line with Intergovernmental Panel on Climate Change's projections that give an 83 per cent chance of remaining below 2°C.

Fanciful target?

"The 1.5°C is a clear guard rail. [Defining] 1.7°C would make 'well below 2°C' a clear guard rail," says Kirchengast. This new "upper limit" of warming would help policy-makers calculate their remaining emissions budgets and plan transition pathways accordingly, he argues. "Policy needs these guidelines."

How difficult would that target be to meet? Limiting warming to 1.7°C is certainly extremely ambitious, given that current policies put the world on track for 2.6°C of warming by the end of the century, yet it isn't completely fanciful. The most optimistic scenario, assuming every country diligently fulfils all of its climate promises, suggests warming would stabilise at 1.9°C by the end of the century, according to a recent United Nations assessment. Getting to 1.7°C would require going beyond existing promises.

But even if some scientists are starting to cluster around the idea that "well below" 2°C actually means a peak temperature limit of about 1.7°C, many people are opposed to codifying a post-1.5°C goal.

We still don't understand the climate system well enough to be confident that we can aim for such specific warming levels, says Carl-Friedrich Schleussner at Berlin-based climate science institute Climate Analytics. There is still considerable uncertainty over how sensitive Earth's systems are to greenhouse gas emissions, which could mean the planet will warm much faster than expected. "We need to be careful not to be overconfident," he cautions. Setting a specific temperature goal "conveys the message that we know exactly where we are going, which is not the case", he says.

Instead, Schleussner says the focus should be on holding governments accountable for any failure of the 1.5°C target, such as by calculating the "carbon debt" accumulated by nations as they exceed that warming threshold. "Unless we are able to establish accountability for failing to limit warming to 1.5°C, I think we are failing the Paris Agreement," he says.

Lower-income nations, particularly the small island states that battled for the inclusion of the 1.5°C temperature goal into the Paris Agreement, are also likely to fiercely resist any attempt to recalibrate global climate ambition to a new target. Ilana Seid, Palauan ambassador to the UN and chair of the Alliance of Small Island States (AOSIS), a UN negotiating bloc, says rising sea levels and the die-off of coral reefs expected at warming above 1.5°C are an existential threat to the countries she represents.

"For AOSIS, the number is 1.5°C. That's our rallying call," says Seid. "There are important reasons for us to be below or at 1.5°C, and that's where we are sticking to... Anything else is just a distraction."

Los Angeles experienced damage from large wildfires in January

APU GOMES/AFP VIA GETTY IMAGES

"Shifting the goalposts while we're still in the game only helps the laggards and lobbyists"

Natalie Unterstell, a former UN climate negotiator for Brazil who is now at climate policy think tank Talanoa, says a shift to adopting a global goal of no more than 1.7°C of warming would "signal to governments and markets that failure is acceptable".

"Shifting the goalposts while we're still in the game only helps the laggards and lobbyists. It fractures political will, confuses public messaging and risks normalising climate failure," she says. "A new temperature target now would create precisely the kind of cognitive fog that fossil fuel interests are counting on."

"The 1.5°C limit is not just a symbolic threshold but a life-or-death line for billions," says Unterstell. "So if anything, this is the moment to double down on action, not downgrade our goals."

Besides the ethical concerns about a move to adopt a new global goal, practically speaking, it would be tremendously difficult to codify 1.7°C into the UN climate system, she points out, requiring a reopening of the rulebooks governing the Paris Agreement and the unanimous support of all 200+ member states. This is unlikely to be an objective at the upcoming COP30 summit in Belém, Brazil, later this year, although the Brazilian presidency will be under pressure to extract bolder climate plans from polluting nations at the summit to close the "ambition gap" between 1.5°C and current warming trajectories.

But should this debate be framed as a contest between 1.5°C and a new, slightly less stringent goal? For Rogelj, limiting warming to 1.5°C will remain an enduring key global target, even if a new temperature goal is also introduced. "1.5°C will never die; the target will remain," he says. "That is because the target is to 'pursue efforts' towards limiting warming to 1.5°C. Having exceeded 1.5°C doesn't take away the goal of pursuing efforts to limit warming to 1.5°C."

When the Paris Agreement was drawn up in 2015, limiting warming to 1.5°C was ambitious but achievable. Now, vanishingly few climate models show a realistic route to meeting this goal without at least some "overshoot" – temperatures rising above 1.5°C for a few decades before being brought back below the limit by the end of the century, using technology like carbon capture. The move to clarify the precise meaning of "well below 2°C" isn't necessarily to provide a replacement target for 1.5°C, but to set an upper temperature threshold for warming in a scenario where the world overshoots, then bring warming back to the 1.5°C limit, says Rogelj.

The question for policy-makers now is this: if 1.5°C is the safety line and 2°C is the cliff edge, how far into the danger zone should we be willing to stray? ▮

Quantum physics

A big blow for big bounce theory

Some physicists believe our universe came from a big bounce following another universe's collapse – but quantum theory could rule this out, finds **Karmela Padavic-Callaghan**

COULD our universe be expanding then shrinking back into a tiny point, reliving a kind of big bang over and over again? Probably not, according to a mathematical analysis that argues that the laws of physics forbid such a cyclic universe.

A key moment in the life of a cyclic universe is the big bounce, an alternative to the big bang as the beginning of the universe we see around us. The big bang starts with a singularity – matter and energy packed into a point so dense that gravity becomes strong enough to elude the laws of physics as we understand them – followed by an endless outwards expansion.

But if the universe began with a big bounce, we could look beyond what we generally think of as the beginning of everything to see another universe contracting, forming an incredibly dense point that isn't quite a singularity before it bounces back out into the expanding universe we live in today.

MARK GARLICK/SCIENCE PHOTO LIBRARY/ALAMY

The big bounce suggests that our universe contracts and expands

Going quantum

This leaves us with some key questions around the history and fate of our cosmos. Must time start with a singularity? And if the big bounce were our universe's beginning, could it also be its future? The first hint at whether that is possible dates to 1965, when Roger Penrose at the University of Oxford proved that general relativity – our best theory of gravity – always breaks down. He was studying black holes, where gravity is also strong enough to break the fabric of space-time. Penrose showed that this is inevitable: when gravity becomes excessively strong, singularities cannot be avoided.

Now, Raphael Bousso at the University of California, Berkeley, has added a key ingredient to strengthen this finding. His analysis accounts for the quantumness of the universe.

Penrose's work didn't include quantum theory, and Bousso says the past calculations that have, pioneered by Aron Wall at the University of Cambridge, only considered very weak gravity. Bousso's analysis doesn't constrain the strength of gravity, and he says it "categorically rules out" cyclic universes. In his view, his work proves that the singularity at the big bang is unavoidable (*Physical Review Letters*, doi.org/pw3j).

"This, in my opinion, is a very significant generalisation of the original theorem by Penrose, and its extension by Wall," says Onkar Parrikar at the Tata Institute of Fundamental Research in India.

Chris Akers at the University of Colorado Boulder says it is a big step forwards because it is valid for "much more quantum physics" than prior work. He says the new work puts big bounce models in a "tighter spot".

Bousso's calculations rely on the generalised second law of thermodynamics, which expands the standard second law to describe the behaviour of entropy in and around black holes. This generalised version hasn't yet been definitively proven, which raises scepticism about the work's implications for the big bounce, says Surjeet Rajendran at Johns Hopkins University in Maryland.

"Understanding our cosmic history is arguably one of the most important scientific endeavours"

In 2018, Rajendran and his colleagues constructed a mathematical model of a bouncing universe that got around the restrictions of theorems like Bousso's. However, their model included more space-time dimensions than we have observed so far, which left several questions about it open.

"Understanding our cosmic history is arguably one of the most important scientific endeavours, and alternative scenarios like the big bounce need to be considered carefully," says Akers.

Making waves

Jackson Fliss at the University of Cambridge says that in bouncing cosmic scenarios, it is usually quantum effects that help the universe rebound from a dense point. Ruling out these possibilities furthers our understanding of a potential theory of quantum gravity and could help us work out "if we really do need quantum gravity to completely describe the interiors of black holes or the big bang", he says.

Rajendran says the best way to determine whether our universe has experienced a cosmic bounce would be through observations of gravitational waves. These ripples in space-time could carry signatures of the bounce, but they would be in frequencies currently inaccessible to gravitational wave detectors. Future generations of detectors could possibly pick these up, but it is uncertain whether some of the planned upgrades to detectors in the US will happen because of budget cuts proposed by the Trump administration.

"It is a question of is the world kind enough to have produced a signal that is big enough [for detection], and is the current world kind enough to allow scientists to build those experiments?" says Rajendran. ∎

The world is losing ground in the fight against measles

Anti-vaccine sentiment has spurred outbreaks of the disease around the globe and could lead to a rise in other preventable illnesses, says **Grace Wade**

A CHILD in the UK died from measles this month. A baby in Canada died from measles in June. Two children in the US have died from measles this year. But it didn't have to be this way. Measles is a preventable disease – yet we have regressed to a point where we are acting as though it isn't. And if we don't move quickly to right the ship, we could see cases of other preventable diseases rise as well.

The US is in the throes of its largest measles outbreak since it eliminated the virus in 2000. More than 1300 cases have been confirmed – the highest number in 33 years. And it isn't alone. In 2024, Europe reported its highest caseload in more than 25 years, doubling that of the year prior. Last year, there were almost 3000 confirmed cases in England, the highest number on record since it began tracking confirmed cases in 1996. Meanwhile, Canada has had more than 3800 reported measles cases this year – more than the previous 26 years combined.

It is an unprecedented situation since the modern dosing system was introduced. Most of these countries haven't seen measles outbreaks this large since the 1980s and 90s, back when most people only received a single dose of the measles, mumps and rubella (MMR) vaccine. After bringing in a two-dose regimen – which is about 97 per cent effective at preventing measles – cases plummeted, and many countries declared measles eliminated around the turn of the century.

That is why this moment is so alarming. Measles is resurging not because we don't know how to stop it, but because we aren't trying. "We have never been in a situation where [the spread of measles] was driven by vaccine hesitancy," says Tina Tan at Northwestern University in Illinois. "This is uncalled for because we have safe and effective vaccines to prevent this from occurring."

Herd immunity against measles, in which most people in an area are protected, occurs when more than 95 per cent of a population is vaccinated. That threshold was met with the two-dose regimen among US children in kindergarten – which usually starts at age 5 – during the 2019-2020 school year. But four years later, coverage fell below 93 per cent.

95%
Proportion of people who need to be vaccinated for herd immunity

85%
Proportion of UK 5-year-olds who had both doses of MMR vaccine

77%
Proportion of 5-year-olds who had the vaccine in Gaines county, Texas

Yet national averages don't tell the full story. Vaccination rates began waning in many US counties before 2019. Peter Hotez at Baylor College of Medicine in Texas and his team flagged falling coverage in Gaines county, Texas – the epicentre of the country's current outbreak – in 2016. Then, MMR vaccination rates for the county were hovering around 95 per cent in kindergarteners. Now, they are less than 77 per cent. "So, we kind of saw this coming for at least a decade," says Hotez. "You really have to go down to the county level to see the horror unfold. That's where you see pockets of very low vaccination rates."

A similar story is playing out across the world. In Canada, the percentage of 2-year-olds with at least one MMR dose fell from almost 90 per cent in 2019 to less than 83 per cent in 2023. In Alberta, a hotspot in the country's current outbreak, rates fell from more than 83 per cent in 2019 to about 80 per cent in 2024 – and some populations in the region report rates as low as 32 per cent.

Meanwhile, less than 85 per cent of 5-year-olds in the UK received both MMR doses in the 2023-2024 school year. In fact, among the 48 members of the Organisation for Economic Co-operation and Development, the UK ranked 30th in measles immunisation rates, while Canada came 39th and the US 4th.

JAN SONNENMAIR/GETTY IMAGES

A young child receives the MMR vaccine in Texas

Loss of status

Vaccine hesitancy is driving these trends, and Robert F. Kennedy Jr., one well-known figure associated with the movement, now leads the US Department of Health and Human Services. Kennedy, who denies being anti-vaccine, has falsely claimed the MMR vaccine carries the same dangerous risks as measles, such as blindness. The risk of complications is much greater with measles infection.

Still, Kennedy has encouraged people to get themselves and their children vaccinated against measles. During a Fox News interview in March, he said the US government is ensuring anyone who wants a vaccine will get one.

It may already be too little, too late. While measles cases are starting to taper off in the US, Hotez fears they could ramp up again when children head back to school. The outbreak is already into its seventh month, and if it lasts for a full year, the US will lose its measles elimination status. The UK has already experienced this. After eradicating measles in 2016, it lost its status two years later, before finally regaining it in 2023.

But Hotez worries the current outbreaks are the tip of the iceberg and vaccine hesitancy will chip away at progress made against other preventable illnesses, such as polio. "I don't think this stops at measles," he says.

Space

Weird galaxies from the early universe have been spotted surprisingly nearby

Jonathan O'Callaghan

UNUSUAL galaxies seen in the early universe have now been spotted in the more recent cosmos, raising questions about their true nature.

Over the past few years, astronomers using the James Webb Space Telescope (JWST) have seen many small, compact and red objects from the first billion years of the universe, known as little red dots (LRDs). They were thought to be linked to some process in the early universe, such as the birth of supermassive black holes found at the centre of most galaxies, including our own.

Xiaojing Lin at Tsinghua University in China and her colleagues have now made an unusual discovery, finding LRDs in the much more recent universe, some 12 billion years after the big bang.

"The discovery illustrates that the conditions that give rise to little red dots are not exclusive to the early universe," says Lin.

The team looked through images taken by the Sloan Digital Sky Survey using a telescope in New Mexico. They identified three objects seen by JWST that looked like LRDs, but, crucially, they were only up to 2.5 billion light years away (arXiv, doi.org/pwr7).

"The conditions that give rise to little red dot galaxies are not exclusive to the early universe"

"They fit every single definition of little red dots," says team member Xiaohui Fan at the University of Arizona. "I don't think there's any doubt they are very similar."

Each of the LRDs is estimated to be about a million times more massive than our sun, with a width roughly similar to our solar system. One of them is nicknamed "The Egg" because of its elongated shape. The team also found a handful of other LRD candidates that have yet to be confirmed.

The discovery is exciting, says Anthony Taylor at the University of Texas at Austin, because it could allow us to get unparalleled information on the nature of LRDs.

The objects are close enough that telescopes like JWST and Hubble should be able to study them much more easily than LRDs from the early universe, which are extremely faint, so could perhaps reveal exactly what they are.

"They're much closer to us, so they're going to show up much brighter," says Taylor.

One possible explanation of LRDs is that they represent the early stages of a supermassive black hole growing inside a galaxy, perhaps when it first switches on and starts voraciously eating material.

It is unclear whether local LRDs would be galaxies that have lain dormant until now, or have recently formed and are just starting to eat large amounts of material. "It's too early to tell on that front," says Taylor.

Fan says the research team hopes to get time with Hubble or JWST to observe these local LRDs in more detail. "We have a proposal for Hubble we're waiting to get approved."

It is possible that LRDs exist throughout the history of the universe too, not just the local and ancient cosmos. "They've been sitting there hidden in plain sight," says Fan. "People just didn't know what they were looking for." ▮

Environment

Human activities have eroded almost all the soil in the Alps

RAPID erosion due to ranching and farming has stripped the Alps of almost all the soil formed since the retreat of glaciers. This soil developed over millennia as plants, microbes and weather transformed hard rock into the carbon-rich foundation of this mountain ecosystem.

"We destroyed the soils at a rate four to 10 times faster than they grew," says William Rapuc at the French National Centre for Scientific Research.

He and his colleagues studied lithium isotopes in sediments from Lake Bourget in the French Alps to reconstruct patterns of soil erosion from the surrounding region over the past 10,000 years. Because certain lithium isotopes are enriched as clay and other minerals form from the parent rock, they can tell you if the soils are developing or eroding, says Rapuc.

WILLIAM RAPUC

The researchers collected sediment from Lake Bourget in France

They compared these patterns of soil erosion from the lake sediment with other records of changing climate and human activity in the region. For the first several millennia after the glaciers receded, changes in climate could explain patterns of soil loss. Then, around 3800 years ago, something shifted.

The researchers identified three surges in soil loss, each of which they think corresponds with a different type of human activity. Between 3800 and 3000 years ago, the surge came from grazing livestock at higher altitudes. Farming at lower altitudes drove the next surge, between 2800 and 1600 years ago, and more intensive agriculture using ploughs and other tools drove the final surge from 1600 years ago until today (*PNAS*, doi.org/g9s7n2). The loss of soil in the Alps accelerates erosion and means the region has less capacity to support vegetation and crops.

The researchers say the shift 3800 years ago marks the start of a "soil Anthropocene" in the region, in which humans are the dominant influence on soil. ▮

James Dinneen

Obesity may come in 11 types

Understanding different forms of obesity could help guide which treatments and prevention strategies work best for individuals, finds **Chris Simms**

IT TURNS out that obesity may be much more complicated than we thought, with the condition potentially existing in up to 11 forms, each caused by distinct biological pathways.

"It's not just about the body mass index or the body appearance; it's more about the biology behind it and how that is related to risk factors," says Akl Fahed at the Broad Institute in Cambridge, Massachusetts.

The World Health Organization defines obesity as having excess fat that poses a risk to health. Whether someone has it is worked out by calculating their body mass index (BMI), a measure of weight relative to height.

As not everyone with obesity has health complications, some researchers have recently suggested introducing a category of "preclinical" obesity. This splits people with the condition into two groups: those with symptoms caused by excess fat, such as breathing difficulties and heart problems, and those who don't have symptoms, but may at a later date. However, these two categories might not be going nearly far enough, according to work by Fahed and his colleagues.

The researchers did a genome-wide association study on more than 2 million people with obesity, with ancestries from all over the world, in which they looked for links between genes and BMI, as well as waist circumference, waist-to-hip ratio and hip circumference. From this, they identified 743 genetic regions linked to obesity, 86 of which hadn't been reported before.

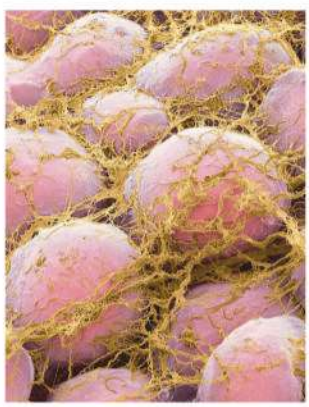
Next, the researchers checked which tissues showed obesity-linked effects caused by the gene variations in those regions, such as on the production of insulin, a hormone that regulates blood sugar levels. They found that these genes fit into 11 clusters, each characterised by distinct biological pathways.

SCIENCE PHOTO LIBRARY/ALAMY

We may be starting to work out why exercise doesn't help everyone lose weight

They are: metabolically unhealthy obesity; metabolically healthy obesity; six types that relate to the production of insulin; and types connected to immune system dysregulation, hormonal control of appetite and body weight, and lipid metabolism

One proposed form of obesity relates to metabolism of lipids



STEVE GSCHMEISSNER/SCIENCE PHOTO LIBRARY

(medRxiv, doi.org/pwvp).

The team calls these clusters endotypes, not subtypes, because the latter are typically mutually exclusive and people could only have one. Instead, an endotype reflects a distinct underlying biological mechanism, but several could coexist within an individual with varying degrees of influence.

The researchers validated their endotypes using separate data on more than 48,000 people in the Mass General Brigham Biobank.

"It is clear that there are many forms of obesity," says Frank Greenway at Louisiana State University in Baton Rouge. We already know that some people with obesity don't lose weight when taking GLP-1 drugs like Ozempic or Wegovy, which suggests that sometimes these aren't addressing the physiological problem, he says.

Gaining a better understanding of obesity and the forms it can take may eventually improve how we approach it. "In acknowledging that there are many different types of obesity, it may be possible to better target treatments and preventative interventions to provide more personalised care," says Laura Gray at the University of Sheffield, UK.

As six of the 11 endotypes are related to insulin, some interventions could be effective across several of the clusters, says team member Min Seo Kim, also at the Broad Institute.

The findings may change our interpretation of studies that looked at how genes and lifestyle interact in obesity, which has generally been treated as one condition, and may alter how such research is done going forward, says Kim.

Gray says there could even be more than 11 endotypes. That number was limited by the genetic regions that we know relate to obesity and the size of the genome datasets used to investigate the condition, she says.

"It's not just about the body mass index; it's more about the biology behind it"

Kim also believes the story might not be quite over yet. "I think it's possible that additional endotypes may be uncovered in the future, as genetic discovery continues," he says.

But Henriette Kirchner at the University of Lübeck in Germany says there could turn out to be fewer than 11 endotypes. She expects we will gain a greater understanding as other researchers try to replicate these findings. "I like the ideas of obesity clusters, but they have to be more refined in the future to be helpful in the clinics." ▮

Zoology

Rare sighting of snow leopard cubs

Graeme Green

SLCF-MONGOLIA SNOWLEOPARD TRUST

TWO snow leopard dens, home to five cubs, have been discovered in Mongolia's Tost mountains, offering a rare opportunity to get data on this threatened species.

Prior to this expedition, which happened in June and July, researchers hadn't been able to visit a snow leopard den anywhere in the world since 2019.

"The dens are in narrow cracks or caves," says Örjan Johansson at the Snow Leopard Trust. "We only get one chance. If the mother returned before we were able to locate the den, we would have to abandon the search. Going back twice would be too intrusive."

2019

The last time researchers visited a wild snow leopard den

Johansson and Buren Nyam, a local field ranger, established the approximate locations of the dens by tracking GPS collars that had previously been fitted to 20 adult female snow leopards.

"A female snow leopard's home range in Mongolia's mountainous South Gobi region is typically about 130 kilometres squared," says Johansson. "Without GPS collars, we'd never find their dens." Even with the collars, areas as large as 60,000 square metres still had to be searched to find them.

Den visits can tell us about survival rates of snow leopard cubs

Snow leopards (*Panthera uncia*) are listed as vulnerable on the International Union for Conservation of Nature Red List of Threatened Species, with an estimated 3920 to 6390 left in the wild. They live in the high mountainous terrain of central Asia across a 2-million-square-kilometre range spanning 12 countries. They face threats such as habitat loss, poaching and killings in retaliation for attacking livestock.

To model the population trajectory of a species, we need to look at things like birth rates and mortality, says Johansson, who worked alongside the Snow Leopard Conservation Foundation. "Den visits are crucial because they're the only way to learn about average litter sizes and cub survival during the first five to six months of life." ▮

Health

Modified microbe could stop kidney stones

Grace Wade

GENETICALLY engineered gut bacteria can break down the compounds that contribute to kidney stones, and the same approach could lead to new treatments for a range of conditions, such as inflammatory bowel disease and colon cancer.

"The gut microbiota has a big influence on our health and being able to manipulate that is a promising avenue," says Weston Whitaker at Stanford University in California. But bacteria introduced into the gut often struggle, because they have to compete with existing microbes, so Whitaker and his colleagues genetically modified a bacterium already abundant in most people's guts, called *Phocaeicola vulgatus*.

The team made three genetic changes. The first enabled the bacterium to break down compounds in food called oxalates, which contribute to kidney stones. The second allowed it to digest a carbohydrate found in red seaweeds known as porphyran. This gave the bacterium a competitive edge over existing gut microbes, most of which can't utilise porphyran. The final tweak made a gene essential for the bacterium's survival dependent upon porphyran. Together, these changes allowed the researchers to control the growth of the microbe – adding porphyran encouraged its spread, while restricting porphyran killed it off.

The researchers fed 12 rats a high-oxalate diet for four days, then treated half of them with the genetically modified bacteria and the other half with a strain that couldn't break down oxalates. Porphyran was added to all of the animals' daily diets. After six days, the rats treated with the engineered bacteria had, on average, 47 per cent less oxalate in their urine compared with the control group.

The team then tested the engineered microbes in nine people with enteric hyperoxaluria, a condition in which the body absorbs too much oxalate, causing recurrent kidney stones. All participants consumed 10 grams of porphyran daily for 28 days. Compared with three people who have the condition but didn't undergo treatment, those who did had 27 per cent less oxalate in their urine, on average (*Science*, doi.org/g9tm9x).

This reduction wasn't statistically significant, probably due to the small sample size, says Whitaker. But other clinical trials suggest a 20 per cent reduction in oxalate is enough to reduce symptoms, he says.

While none of the participants experienced serious side effects, those treated with the genetically engineered gut microbe were more likely to have mild gastrointestinal problems, such as diarrhoea.

Genetic analysis of the human participants' gut microbiomes revealed that eight weeks after stopping the supplement, four of them still had bacteria capable of digesting porphyran. This indicates the engineered bacteria had swapped genetic material with existing gut microbes. This shouldn't cause any safety concerns, but is an issue to address in future studies, says Whitaker.

"I think this [approach] is a real breakthrough," says Christoph Thaiss, also at Stanford University. It's a strategy that could help treat a range of conditions, he says. ▮

Archaeology

Neanderthals had local food cultures

Cut marks on bones reveal that Neanderthal groups had their own distinct butchery style

Chris Simms

NEANDERTHALS may have had traditional ways of preparing food that were particular to each group. Discoveries from two caves in northern Israel suggest the residents butchered the same kinds of prey in their own ways.

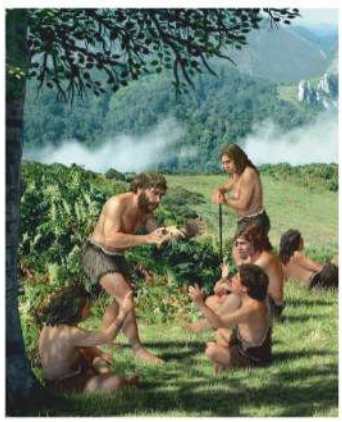
Modern humans, or *Homo sapiens*, weren't the first hominins to prepare and cook food. There is evidence that Neanderthals used flint knives to butcher what they caught, cooked a wide range of animals and spiced up their menu with wild herbs. To learn more about Neanderthal food culture, Anaëlle Jallon at the Hebrew University of Jerusalem and her colleagues examined evidence at the caves of Amud and Kebara in northern Israel.

These sites are just 70 kilometres apart and provide the chance to examine local cultural differences. Stone tools, food remains and hearths found at each site reveal that Neanderthals occupied both caves, probably in winter, during the same time period.

"You find the same species of animals to hunt and it's more or less the same landscape," says Jallon. "Neanderthals at both ate mostly gazelles and some fallow deer that they complemented with a few bigger animals."

There are a few differences, though. For example, bones reveal that a greater amount of large prey was hunted at Kebara, and more kills were carried back to that cave to be butchered.

Jallon and her colleagues used microscopes to inspect bones from layers of sediment at the two sites from between 50,000 and 60,000 years ago, examining the cuts formed by stone tools.



MAURICIO ANTON/SCIENCE PHOTO LIBRARY

ANAËLLE JALLON 2025 ET AL. 2025

Cut marks made by Neanderthals on a bone found in Israel show different groups had varying approaches to butchery

They found that even though the flint tools used were similar at both sites, the patterns of cuts were different (*Frontiers in Environmental Archaeology*, doi.org/pwvn). "The cuts tend to be more variable in their width and depth in Kebara, and in Amud they are more concentrated in big clusters and they overlap each other more often," says Jallon.

To assess if the differences could be down to butchering different prey, the researchers also looked specifically at long bones from gazelles found at both sites. These had the same differences.

"We are talking about two groups who live very close – but in one site they seem to be cutting closer to the bone, getting all the meat off," says Ceren Kabukcu at the University of Liverpool, UK.

Previous research that looked at cut marks on bones from more recent societies suggests that the kind of variation seen in Neanderthal butchery isn't down to a lack of expertise, but to a difference in technique.

Jallon thinks the contrast is best explained by deliberate choices. It could be that Neanderthals at Amud made their meat harder to process by, for example, drying it or letting it hang before cooking, she says, which would have meant they needed more cuts to get through it or a larger team of people to butcher the meat.

"The fact that there might be differences and some nuance on how technology is used in daily life is not entirely shocking," says Kabukcu. "I think as this question is investigated, we might see more and more nuance at several sites of the Middle Palaeolithic." ▮

Animal behaviour

Small worms develop a taste for microplastics

PREDATORS can learn to prefer eating prey that is contaminated with microplastics, even when clean food is available. This behaviour could have implications for the eating habits and health of entire ecosystems, including ours.

Researchers discovered this preference for plastic after studying the eating habits of small roundworms called nematodes (*Caenorhabditis elegans*) over several generations. When offered their usual diet of bacteria, as well as the same microbes contaminated with microplastics, the first generation of nematodes opted for the cleaner alternative. However, exposure to plastic-laced food over multiple generations altered their preferences (*Environmental Science and Technology Letters*, doi.org/pw3f).

"They actually start to prefer contaminated food," says Song Lin Chua at Hong Kong Polytechnic University.

"Exposure to plastic-laced food over multiple generations altered their preferences"

Why did the worms develop a taste for plastic? As creatures without true vision, nematodes rely on other senses to locate their food, such as smell. "Plastics may be part of those smells," says Chua. After prolonged exposure, they may recognize microplastics as "more like food" and choose to eat them, he says.

Chua points out the behaviour is "more like a learned response" than a genetic mutation, and therefore potentially reversible. "It's more like a matter of taste," he says, likening it to a human's affinity for sugar. He says that, in theory, this could be reversed in future generations, but that it still warrants further study.

As one of the most common types of animals in the world, the nematodes' dietary preferences could have much larger implications for the health of their ecosystems.

"This will pass down the food chain," says Chua, who notes the behaviour could create a kind of "ripple effect" that will also affect humans' diets. "Eventually it will still come back to us," he says. ▮

Meagan Mulcair

Geology

Ancient rocks show earliest evidence of tectonic activity on Earth

Alex Wilkins

ROCKS in Australia preserve evidence that plates in Earth's crust were moving 3.5 billion years ago, a finding that pushes the beginnings of plate tectonics back by hundreds of millions of years.

Today, around eight vast, rigid plates of rock at the surface of the planet, plus some smaller plates, are pulled or pushed along a softer layer of rock beneath. But geologists disagree over how many plates there once were, when they started moving and how they used to move. The strongest evidence for a start date was about 3.2 billion years ago.

Geologists can use hints from the chemical composition of rocks to infer how those rocks moved in the past. However, there is little record of how early plates may have moved relative to each other.

Now, Alec Brenner at Yale University and his colleagues say they have found unambiguous evidence of relative plate motions around 3.5 billion years ago in the eastern Pilbara craton in Western Australia. The researchers tracked how the magnetic field of the rocks, which was aligned with Earth's, moved over time, similar to how a compass in the rock would change its needle direction as the ground moved.

Brenner and his team first dated the rocks by analysing the radioactive isotopes they contain, then proved the rocks' magnetisation hadn't been reset at some point. By tracking how this magnetisation had moved, they could show that the entire rock region had migrated over time, at a rate of tens of centimetres a year. Then, they compared this with rocks that had been dated and tracked using the same technique in the Barberton Greenstone Belt in South Africa, which showed no movement.

The Pilbara craton hints that plate tectonics began 3.5 billion years ago

ELIZABETH CZITRONYI/ALAMY

"It means that there had to have been some kind of plate boundary in between these two [regions] to accommodate that relative motion. That's plate motion, definitionally," Brenner told the Goldschmidt geochemistry conference in Prague, Czech Republic, on 9 July.

"The Pilbara, around 3.48 billion years ago, moves from mid-to-high latitudes to very high latitudes, actually within the area of the geomagnetic pole, and probably close to around where Svalbard's latitude is today, in just a few million years. While the Barberton is just sitting there, doing nothing much at all on the equator," said Brenner.

"If two plates are moving relative to each other, there has to be an awful lot of stuff going on between as well," says Robert Hazen at the Carnegie Institution for Science in Washington DC. "It can't just be an entirely local thing."

At the very least, the finding implies the existence of a tectonic boundary, says Michael Brown at the University of Maryland. However, he says that the motion of the rocks appears markedly different from what we understand as plate tectonics today. "Essentially, the Pilbara [plate] goes steaming up to higher latitudes and stops dead, which is unusual in any plate tectonic context." ▮

Space

Gobbling up dark matter may help stars live forever

STARS near the centre of our galaxy may be almost immortal because they eat dark matter for energy.

More than two decades ago, astronomers noticed something odd about the stars near the centre of the Milky Way. First, the light they emit suggests they are younger than expected based on their mass, a problem dubbed the "paradox of youth". Second, older stars are unusually scarce in this region, an issue called the "conundrum of old age".

Now Isabelle John at Stockholm University in Sweden and her colleagues have used a computer simulation to show that dark matter may help resolve both puzzles.

The galactic centre is known to be exceptionally dense with dark matter, so the researchers simulated what happens when a dark matter particle hits a star. They found that each such particle loses energy and becomes trapped within the star when it collides with the nuclei of the star's atoms. If other dark matter particles are already stuck in the same place, they end up annihilating each other, and every annihilation produces a burst of energy that makes the star brighter.

The reason stars age is that they run out of fuel for nuclear fusion, but dark matter could be an additional energy source that extends a star's life. In fact, there is so much dark matter near the galactic centre that this process could effectively make stars immortal, says John. The work will appear in *Physical Review D*.

"Dark matter could be an additional energy source that extends a star's life"

Collecting more telescope data and factoring in new findings about dark matter could help pinpoint which stars in the Milky Way's centre might be able to live forever.

Marc Pinsonneault at the Ohio State University says we should consider what the simulations mean for stars that are further away from the galactic centre. We have very detailed observations about stars closer to Earth, so any predicted effects of dark matter should also be checked against this data, he says. ▮

Karmela Padavic-Callaghan

Mental health

Brain changes may lead to anorexia

In children with anorexia nervosa or other restrictive eating disorders, changes in the brain's outer layer don't seem to be due to lack of nutrition alone, finds **Grace Wade**

CHILDREN with anorexia nervosa have widespread brain changes that can't be explained by their eating patterns alone. The finding brings us closer to identifying the neurological processes behind the condition, which could lead to better treatments for it.

Anorexia nervosa, an eating disorder characterised by severe calorie restriction and distorted body image, is poorly understood. Previous research has shown that the brain's outer layer, called the cortex, is significantly thinner in people with the condition than those without it. But it isn't clear the degree to which these changes are the result of malnutrition or an indication of the cause of anorexia.

Clara Moreau at the University of Montreal in Canada compared brain scans from children with anorexia with those with avoidant/restrictive food intake disorder (ARFID). Both conditions involve severe food restriction and weight loss, but ARFID isn't motivated by body image concerns or a fear of gaining weight. Instead, people with ARFID avoid food due to sensory issues, a lack of interest in food or fear of negative consequences like choking, vomiting or gastrointestinal pain. Because both disorders can lead to low body weight and malnutrition, comparing them could reveal brain changes unique to each condition and those caused by starvation, says Moreau.

The researchers collected brain scans from 124 children with anorexia, 50 with ARFID and 116 without an eating disorder. All of the children were under 13 years old and living in France. They then compared the magnitude of brain differences between children with eating disorders and those without.

On average, children with anorexia had significantly thinner cortices than those without an eating disorder. After accounting for body mass index (BMI),

32

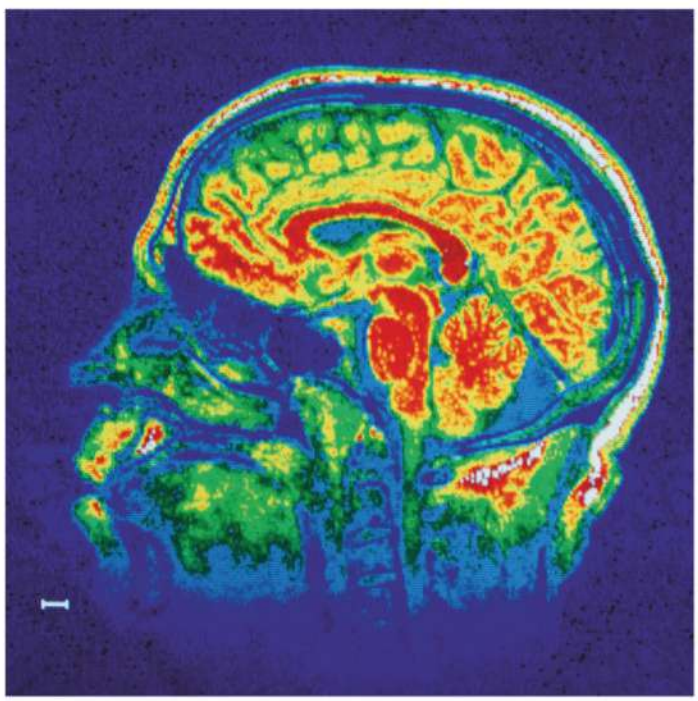
Number of brain regions with thinning in those with anorexia

anorexia was associated with cortical thinning in 32 brain regions, with the greatest effect seen in the superior parietal lobule, an area involved in processing sensory information.

"That can make sense because we know that patients with anorexia have disturbed perception of their body weight, of their size," says team member Anaël Ayrolles at the University of Paris.

These changes are similar to those seen in older adolescents or adults with anorexia, says Moreau. "The effect size is one of the largest in psychiatry," she says. "I mean, it looks like they have accelerated [brain] ageing or early Alzheimer's." They don't have Alzheimer's disease symptoms – the cortical thinning seen is just of a similar magnitude. "If their BMI is restored, we can see some brain restorations as well," says Moreau. "Their brain is able to get better after treatment. Not all of them, but most of them."

In contrast, there were no significant differences in cortical thickness between children with ARFID and those without a condition. "We were thinking we would find some overlap with anorexia that could be reflecting BMI," says Moreau. "But that's not what we found. We didn't find many similarities between the conditions." It isn't clear why that is, especially as this is the first-ever brain-imaging study of ARFID. Given ARFID usually develops before the age of 5, the brain may adapt to low food intake, says Moreau.



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A brain scan of a child with no known neurological conditions

Links with OCD

The researchers then compared these brain differences with those seen in previous studies of other conditions, such as obsessive-compulsive disorder (OCD), ADHD and autism. They found significant correlations between anorexia and OCD, while ARFID had similar changes to those seen in autism (*Nature Mental Health*, doi.org/g9tddx). Moreau says this makes sense, as sensory sensitivities are common in both autism and ARFID. Meanwhile, obsessions, rituals and preoccupations manifest in both OCD and anorexia.

However, people with OCD and anorexia tend to have other mental health conditions as well, says Joanna Steinglass at Columbia University in New York. In fact, roughly 14 per cent of people with anorexia have also been diagnosed with OCD. This makes it challenging to disentangle whether there are true neurological similarities between them or if other mental health conditions underlie the association.

"We have been very, very cautious not to overinterpret our results," says Ayrolles. Still, these findings suggest that malnutrition is unlikely to explain all of the brain changes seen in anorexia. "Any psychiatric illness is a brain-based illness and understanding that helps patients grapple with what they're going through. It helps patients oftentimes blame themselves a little bit less," says Steinglass. "And it helps us develop better treatments."

Health

Don't fear your child's afternoon nap

Chris Simms

MOISES SAMAN/MAGNUM PHOTOS

A SHORT nap during the day seems to increase the overall amount of sleep a young child gets, rather than being a serious threat to night-time slumbers.

Babies and young children typically nap during the day, a habit that has been linked to the development of early memories. This trend usually stops between the ages of about 3 and 5, but the timing varies, leaving many parents unsure as to whether their child should nap or not.

In France, children start a form of preschool at 3 years old, which presents a dilemma of whether staff should let them nap. "Some parents and teachers are concerned that napping during the day might interfere with night-time sleep or reduce valuable learning time," says Stéphanie Mazza at the University of Lyon in France.

To see if naps meaningfully disrupt night-time sleep, Mazza and her colleagues gave wrist-worn sleep trackers to 85 children aged 2 to 5 from six French preschools and measured their sleep over an average of 7.8 days.

This data, combined with sleep diaries filled in by parents, revealed that an increase in nap

Many parents worry that a daytime snooze means less sleep at night

time of 1 hour was linked to getting 13.6 minutes less sleep at night, on average, and pushed back the time at which the child got to sleep at night by 6.4 minutes. On days when children napped, their overall sleep time across the day increased by 45 minutes (Research Square, doi.org/pwhh).

"Naps resulted in a significant increase in total daily sleep time, bringing children closer to the recommended international sleep duration for a 24-hour period," says Mazza. The World Health Organization recommends that children of this age should sleep for 10 to 13 hours per day.

"Parents shouldn't worry if their child still needs a nap before the age of 6," says Mazza. "Rather than viewing naps as disruptive, they should be recognised as a valuable source of rest, especially when children are exposed to stimulating environments."

"To me, this says – if they can nap, let them nap," says Rebecca Spencer at the University of Massachusetts, Amhurst. ▮

Mathematics

Long-standing knotty problem finally solved

Matthew Sparkes

LARGER and seemingly more complex knots created by joining two simpler ones together can sometimes be easier to undo, a surprise finding that invalidates a conjecture posed almost 90 years ago.

"We were looking for a counterexample without really having an expectation of finding one," says Mark Brittenham at the University of Nebraska at Lincoln. "In the back of our heads, we were thinking that the conjecture was likely to be true. It was very unexpected and very surprising."

Mathematicians like Brittenham study knots by treating them as tangled loops with joined ends. One of the most important concepts in knot theory is that each knot has an unknotting number, which is the

"We thought that the conjecture was likely to be true. It was very unexpected"

number of times you would have to sever the string, move another piece of the loop through the gap and then rejoin the ends before you reached a circle with no crossings at all – known as the "unknot".

Calculating unknotting numbers can be computationally intensive, so it can be helpful to break knots down into two or more simpler knots to analyse them.

But a long-standing mystery is whether the unknotting numbers of the two knots added together would give you the unknotting number of the larger knot. Intuitively, it might make sense that a combined knot would be at least as hard to undo as the sum of its constituent parts, and in 1937, it was conjectured that undoing the combined knot could never be easier.

Now, Brittenham and Susan Hermiller, also at the University of Nebraska at Lincoln, have shown that there are cases when this isn't true (arXiv, doi.org/pwhm). "First, we found one, and then quickly we found infinitely many pairs of knots for which the connected sum had unknotting numbers that were strictly less than the sum of the unknotting numbers of the two pieces," says Hermiller.

"We've shown that we don't understand unknotting numbers nearly as well as we thought we did," says Brittenham. "There could be – even for knots that aren't connected sums – more efficient ways than we ever imagined for unknotting them. Our hope is that this has really opened up a new door for researchers to start exploring."

While finding and checking the counterexamples involved a combination of existing knowledge, intuition and computing power, the final stage of checking the proof was done in a more simple manner: tying the knot with a piece of rope and physically untangling it.

Andras Juhasz at the University of Oxford, who previously worked with AI company DeepMind to prove a different conjecture in knot theory, says that he and the firm had tried unsuccessfully to crack this problem about additive sets in the same way, but with no luck. "We spent at least a year or two trying to find a counterexample and without success, so we gave up," says Juhasz. "It is possible that for finding counterexamples that are like a needle in a haystack, AI is maybe not the best tool." ▮

Health

How human eggs stay fresh so long

Slower natural cell processes may explain why eggs have unusually long lifespans

Meagan Mulcair

HUMAN eggs seem to dispose of their waste more slowly than other cells do, which may help them avoid wear and tear – and explain why they live longer.

Every woman is born with a finite number of egg cells, or oocytes, which need to survive for about five decades. For cells, that is an unusually long time. Although some human cells, like those in the brain and eyes, can live as long as you do, most have much shorter lifespans, in part because the natural processes that allow them to function also damage them over time.

Cells must recycle their proteins as a form of necessary housekeeping – but it comes at a cost. The energy consumed in this process can generate molecules called reactive oxygen species, or ROS, which cause random damage in the cell.

"This is damage happening in the background all the time," says Elvan Böke at Centre for Genomic Regulation in Spain. "The more ROS there is, the more damage there's going to be."

But healthy eggs seem to avoid this issue. To find out why, Böke and her colleagues studied harvested human eggs under a microscope. The cells were placed in a liquid with fluorescent dyes, which bind to acidic cellular components, called lysosomes, that behave as recycling plants.

The bright dye revealed the waste-disposing lysosomes in human eggs were less active than the same components in other human cell types or those in the egg cells of smaller mammals, like mice (*The EMBO Journal*, doi.org/g9tb96). The team says this may be a form of self preservation.

Slowing down their waste-disposal mechanism may be just one of many ways human egg cells achieve their relatively long lifespans, says team member Gabriele Zaffagnini at the University of Cologne in Germany.

"Protein degradation is essential for cell survival, so it 100 per cent does affect fertility"

Böke speculates that to avoid damage, the human oocytes "put a brake on everything". If all cell processes run slower in human egg cells, she says, this could result in lower levels of harmful ROS, and therefore less risk of damage.

Since delaying the protein-recycling process seems to help egg cells maintain their health, failing to do so could explain what makes some oocytes unhealthy. "The way I see this is, it could be a clue into why human oocytes really become dysfunctional after a certain time," says Emre Seli at Yale School of Medicine. "It could be a segue into advanced assessment of all the things that go wrong in human oocytes."

Assessing egg health in this way could eventually improve fertility treatments. "We do know that protein degradation is essential for cell survival, so it 100 per cent does affect fertility," says Böke. She notes the study focused on healthy eggs; she says work to compare those cells with eggs from people affected by complications with fertility is ongoing. "If there's high ROS in the cell, there are poor IVF outcomes," she says.

Human egg cells are still not well understood, because they are difficult to study. "[They are] hard to work with, because the sample limitation is an issue," says Böke. ▮

Marine biology

Underwater volcanic brine pools could be home to extreme life

SUPER-SALTY underwater lakes rich in carbon dioxide could host extreme life forms unlike any others on Earth.

Water rich in salt sinks to the bottom of the ocean and can collect in depressions in the sea floor as a liquid lake that is distinct from the water above. The unique chemical make-up of these brine pools – low in oxygen and rich in certain minerals – makes them places where extreme microorganisms can evolve and thrive.

Now, Froukje van der Zwan at King Abdullah University of Science and Technology in Saudi Arabia and her colleagues have discovered a new type of brine pool that is warm, rich in CO_2 and appears to be fed by underwater volcanoes.

DR. KATRIN LINSE

The life found in nearby vents gives clues to what we may find in volcanic brine pools

On a recent expedition to two underwater volcanoes in the Red Sea, Hatiba Mons and Mabahiss Mons, van der Zwan and her colleagues found several brine pools near the summit of the volcanoes, more than a kilometre above the surrounding sea floor and about 5 kilometres away from any mineral deposits that may have increased the water's salinity. They also found nearby areas with hydrothermal vents that were releasing mineral-rich water at around 60°C (140°F).

Sampling showed that the pools were warmer than the surrounding water and had elevated levels of metal elements such as zinc and manganese. The team presented its findings at the Goldschmidt geochemistry conference in Prague, Czech Republic, on 8 July.

The researchers are currently analysing microbial samples taken from the pools to see how life forms might be adapted to the extreme environment. At the nearby hydrothermal vents, they found thick mats containing microbes much larger than any others known in marine environments, as well as polychaete worms and amphipods.

Life in the pools may provide clues to how life might develop in extreme alien environments. ▮

Alex Wilkins

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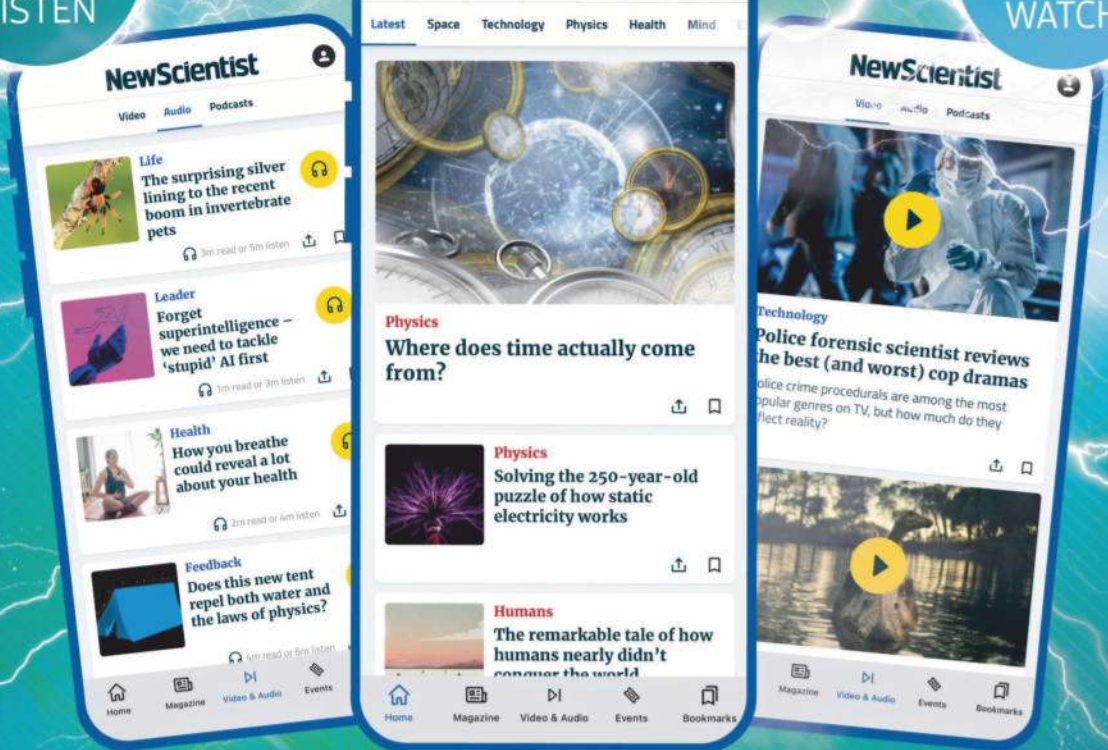

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Comment

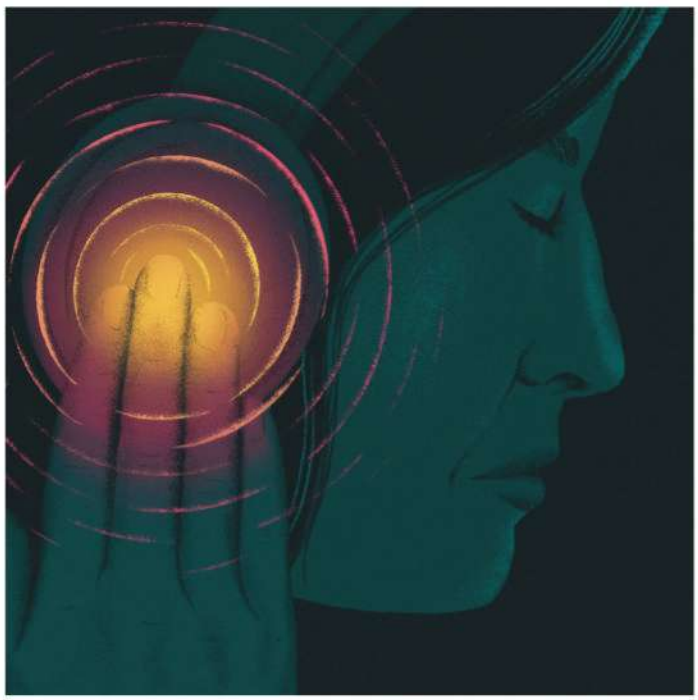
Play on

Music is a powerful, evidence-based tool for promoting mental well-being. It should play a much bigger role in society, says **Stefan Koelsch**

MUSIC isn't just entertainment. It is one of the most accessible and powerful ways to regulate our mental state, yet we continue to underestimate its potential. It is time for society to embrace the therapeutic power of music not only in clinical settings, but also in our everyday lives.

We already know that music can stir emotions – soothe our nerves, lift our mood, make us cry. But over the past few years, research in my lab at the University of Bergen, Norway, suggests it can change the content of our thoughts. In our 2019 study, participants listened to heroic- or sad-sounding music while their minds wandered. The results were striking: the uplifting music triggered energising, constructive thoughts, while the sad music evoked calmer or more demotivating ones. This influence isn't just a curiosity; it has consequences for mental health.

Our minds frequently wander, with one Harvard University study finding that we daydream for nearly half the time we are awake, and that we are generally less happy when this is happening. Even pleasant thoughts don't improve mood significantly. Why? Because during these periods, the brain's default mode network (DMN) takes over. This supports imagination, memory and reflection, but often drifts into repetitive, intrusive and negative thought loops: the 3am worries, the regrets on the train ride home.



ELAINE KNOX

In recent brain-imaging studies, we showed that negative daydreams, especially during sad music, engage the brain's pain system as well as the DMN. Certain areas, like the posterior cingulate sulcus, seem to mediate this link. Upsetting thoughts, it turns out, are more than metaphorically painful – they recruit the same networks as physical discomfort.

Fortunately, the DMN has a natural counterpart: the executive network, which supports focus and goal-directed behaviour. The two systems are anticorrelated, meaning when one is active, the other quiets down. And music, especially when we actively engage with it, can shift us into this more adaptive mode. Whether by tapping along, breathing in rhythm or humming internally, we redirect attention, disrupt negative thought loops and give our minds a cognitive "reset".

This does more than improve mood. In a 2023 study, we found that people who tapped along to music experienced significantly less physical pain in experiments where a short burst of pressure was applied to their fingernails than those who merely listened. The combination of musical immersion and motor synchronisation boosted pain-reducing effects to a clinically meaningful degree.

These findings suggest that musical engagement is a kind of pleasurable meditation. And evolution may have shaped our brains to seek music for this very reason, enhancing resilience as well as increasing social bonding.

The thinking behind all this is laid out in my new book, *Good Vibrations: Unlocking the healing power of music*. I also share simple techniques like music-focused breathing and mood-steering playlists that can help regulate emotion, reduce anxiety and bring relief from negative thought loops.

If music can do all this, it needs to be recognised as far more than the lifestyle accessory it can look like. It should be integrated into schools, public health strategies and everyday routines. Music therapy should be more widely accessible, and music education (often first in cuts to curricula) seen as it really is: a form of care for the brain, emotional literacy and social medicine.

Music is always within reach. The next time your thoughts spiral or stress begins to bite, instead of reaching for your phone's news app, put on your favourite song. Your brain – and your society – might just thank you. ▮

Stefan Koelsch is a professor of psychology at the University of Bergen, Norway

This changes everything

Social media is dying A new information ecosystem is on the rise, featuring closer connections, cosy media and worker-owned websites, writes **Annalee Newitz**

Annalee Newitz is a science journalist and author. Their latest book is *Automatic Noodle*. They are the co-host of the Hugo-winning podcast *Our Opinions Are Correct*. You can follow them @annaleen and their website is techsploitation.com

Annalee's week

What I'm reading
Moudhy Al-Rashid's brilliant history of Mesopotamia, Between Two Rivers.

What I'm watching
A new podcast about media from ex-CNN reporter Oliver Darcy called Power Lines.

What I'm working on
Writing articles for collectively run publication Flaming Hydra.

This column appears monthly. Up next week: Rowan Hooper

ONE of the not-funny ironies of the 21st century has been that everything we thought was social media is actually just mass media, except it's terrible and broken. Luckily, journalists and creators are finally figuring out how to leave the old media models behind and enter the future.

The term "mass media" became popular in the 1920s to describe pop culture in the age of industrial production. Mass-produced books, movies and radio shows created a paradigm for audiences where thousands or even millions of people could experience the same exact piece of media at the same time. Before the 20th century, most people experienced their entertainment live, in theatres, bars and concert halls, where the performance was always slightly different. But a movie or radio show was the same for everyone, no matter when or where you experienced it. You could buy standardised media products for the masses, just like shoes or cars.

Social media didn't change this formula. Platforms such as X, Facebook and TikTok were made for mass consumption. Every post, video and livestream is a product aimed at the broadest possible audience. Yes, you can target your media at certain demographics if you like, or create filter bubbles. But the whole reason why follower counts matter is because we are still in a mass media mindset, looking to see who can deliver content to the largest number of people. That isn't "social" anything. It's mass production under a different name.

What if we tried to make media that was truly social, without AI slop and political scapegoating? One possibility is something called cosy media, which refers to apps or other content designed to help you connect with small groups of friends, often in a friendly, calming environment. Imagine the media equivalent of meeting up with friends to knit or play cards and talk beside the fire.

The game *Animal Crossing*, with its low-stakes missions and cute, natural setting, is an iconic cosy-media experience. App developers are trying to reproduce that aesthetic in social apps too – anything from a group chat to an online book club can be cosy. But it isn't just about aesthetics. A cosy social app is designed to limit your social interactions with random strangers, steering you towards trusted friends instead.

"Cosy media helps you connect with small groups of friends, often in a friendly, calming environment"

I have been using the photo-sharing app Retro a lot recently. Unlike Instagram, where Retro's creators cut their teeth, Retro is primarily intended to be used among small groups of trusted friends. And there are no algorithms pushing videos from strangers into your feed. When I open Retro, I feel like I'm hearing from my pals rather than tuning into a fire hose of nonsense and advertising. Nothing I post there is intended to go beyond a few dozen people. Like a group chat app, Retro lets you choose who you want to talk to in a mindful way, rather than shouting into a giant algorithmic void.

We may need cosy media to soothe ourselves in a frenetic, scary time, but we also need news and analysis. Unfortunately, many of our trusted news sources are falling apart. Journalists in the US, where I live, are leaving media outlets such as *The Washington Post*, *The New York Times* and National Public Radio, citing diminishing resources and editorial freedoms.

Some, like economist Paul Krugman and technology researcher Molly White, have created successful, crowdfunded newsletters for their work. But most journalists don't want to go solo: good reporting and analysis often require a solid team. That is why many are forming worker-owned co-operatives to start new publications, where they get institutional perks like lawyers, editors and helpful colleagues. This model is also good for consumers, who don't want to search out and subscribe to dozens of individual newsletters just to catch up on current issues.

The worker-owned co-op model has already been a smashing success for several publications that started in the past couple of years. 404 Media is one such site, breaking news in the worlds of tech and science. Defector is a worker-owned co-op that covers sports and politics; Aftermath covers games; Hearing Things covers music. Flaming Hydra (to which I contribute) is a collective that publishes political analysis, interviews and cultural criticism. Coyote Media is about to launch in the San Francisco Bay area, to cover local news. And there are many other worker-owned local media co-ops forming.

Like mass media, social media often leads to loneliness and isolation. The point of cosy media and worker-owned publications is to rebuild community and trust. We might be witnessing the birth of a new information ecosystem, designed to help us understand the world again. ▮

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How science and farmer partnerships are securing the future of a breakfast staple

For over 90 years, Weetabix has been a British breakfast institution and remains the nation's number one cereal for good reason. To ensure it stays that way for the next 90, the company is turning to science and a unique partnership with local farmers to tackle the food industry's greatest challenge: sustainability.

"We want to make our supply chain sustainable for the climate, our growers, consumers and the environment," says Peter Chandley, Head of Quality and Food Safety at Weetabix. The company's biggest source of Scope 3 greenhouse gas emissions comes from growing wheat, with 60–70% of that footprint originating from fertiliser use.

To address this, Weetabix assessed the carbon footprint of wheat supplied by its grower group, all within 50 miles of the factory. The results showed these farmers already had significantly lower greenhouse gas emissions than the UK average—up to 35% lower.

To go further, Weetabix established a 'Pioneer Growers Group'—a small collective of innovative farmers who collaborate with the company to trial more sustainable agricultural methods. "A lot of it needs to be farmer-led," Chandley explains. "They're the experts and love learning from each other."

The focus is on robust data. Working with agricultural data company Map of Ag, the group is measuring the impact of techniques designed to reduce nitrogen fertiliser use. Initial findings show these practices not only cut emissions by a further 20%, but may also improve soil health and resilience to climate events.

This targeted approach has co-benefits beyond carbon reduction, with the potential to improve local water and air quality. "We need to continue validating good practice," says Chandley. "But it also shows that agri-food is an exciting, dynamic, high-tech sector. We need new scientists and engineers to help solve these challenges and secure our future."

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INES PAPERT

STEVE MONKS

THE MARTIN AND OSA JOHNSON SAFARI MUSEUM, CHANUTE, KANSAS

New heights

Thames & Hudson

MOST people would find a 1200-metre wall of ice on a mountain peak intimidating. But for decorated ice climber Ines Papert, scaling the peak of Kyzyl Asker – a remote mountain on the border between China and Kyrgyzstan – was a dream. It took three attempts before she and fellow climber Luka Lindič summitted it in 2016 (far left), becoming the first known people to climb a precipitous route the pair dubbed "Lost in China".

Papert is one of more than a dozen female mountaineers whose daring expeditions to the world's greatest peaks are featured in *Mountaineering Women: Climbing through history* by Joanna Croston.

Another is mountaineer Elizabeth "Lizzie" Le Blond, photographed climbing a mountain in the Swiss Alps in 1889 in a full skirt (top, near left). Le Blond, who made 20 record-breaking ascents, also helped form the Ladies' Alpine Club in 1907 to offer support to female mountaineers in this male-dominated sport.

Croston's book also features Lydia Bradey, who was the first woman to climb several routes in California's Yosemite National Park in the 1980s. Here (bottom, near left), she is pictured midway up a route on the iconic face of Half Dome. In 1988, she became the first woman to summit Mount Everest without supplementary oxygen. The Tibetan name for Everest is *Qomolangma*, which means "goddess mother of the world".

Mountaineering Women: Climbing through history will be released in the UK on 7 August and internationally on 16 September.

James Dinneen

A synthetic sisterhood

A novel about a female robot just won a prestigious literary award. But she is hardly the first of her kind, says **Sophie Bushwick**

THIS year's Arthur C. Clarke award for the year's best science fiction novel was awarded last month to Sierra Greer's *Annie Bot*. Over the course of the novel, Annie, a sentient sex robot programmed to adore her selfish owner, gradually develops a sense of personhood – but she is hardly the first artificial woman to do so. Although the earliest fictional female robots were little more than wind-up toys, they have steadily gained substance until more recent artificial women, like Annie, have become as complex as their human counterparts.

Artificial people are both ancient and ubiquitous. "Basically every culture around the world since recorded history has told stories about automatons," says Lisa Yaszek at the Georgia Institute of Technology. They usually belong to three categories, she says. Many are manual workers or weapons, but female creations tend to fall into the categories of domestic and sexual companions. In Greek myth, Galatea is the statue of a perfect woman who comes to life after her creator Pygmalion falls in love with her.

Throughout history, these fictional automata have had real counterparts: novelty machines that mimicked living creatures. By the 18th century, technological advancements made some of these devices beautifully realistic, so it is no wonder people began to imagine fictional automata that could be mistaken for the real thing. One of the eeriest such visions was E. T. A. Hoffmann's 1817 short story *The Sandman*. The lovely Olympia captivates Nathaniel, despite her uncanny stiffness and passivity. Olympia is eventually revealed to be a moving doll, a discovery that drives Nathaniel to madness and death.

In the 19th century, artificial women often played the same role human women were expected to fill: domestic companions for men. In 1886's *The Future Eve*, Auguste Villiers imagined a modern-day Pygmalion. An inventor, disgusted with the imperfections of real women, builds a flawless mechanical one that is imbued with a soul. Alice W. Fuller mocked this idea in the 1895 short story "A wife manufactured to order". A man ditches his opinionated girlfriend in favour of an agreeable machine – but grows frustrated with her sycophancy.

This dream of a perfectly pliant Galatea has carried on through decades of fiction. "The ideal is a very obedient, compliant, available woman with absolutely no wishes or wants of her own," says Julie Wosk, author of *My Fair Ladies: Female robots, androids, and other artificial Eves*.

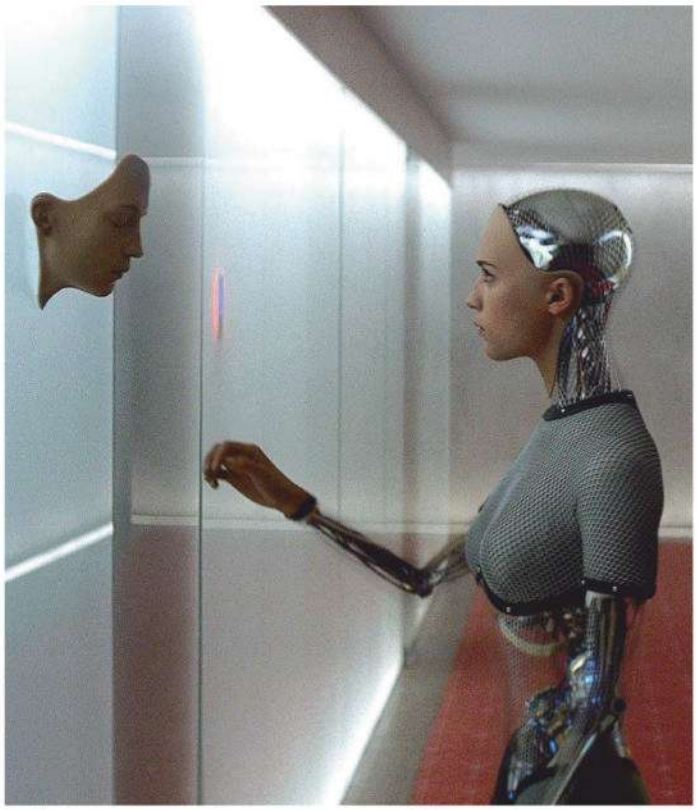
As authors dreamed up automata, the industrial revolution was building up steam, and people worried that newly invented machines would outcompete humans. Fiction like Samuel Butler's 1872 novel *Erewhon* even teased the idea that machines might evolve the ability to think. At the beginning of the 20th century, this anxiety culminated in two influential works of fiction.

In 1920, playwright Karel Čapek's *R.U.R.* portrayed a society that attempted to elevate all people to the upper classes – by leaving the labour to synthetic people he dubbed "robots", from the Czech word *robota,* meaning serfdom or forced labor. As Butler's Erewhonians predicted, the robots of *R.U.R.* finally revolt against their creators.

Several years later, Thea von Harbou published *Metropolis*, adapted into the seminal 1927 film by Fritz Lang. A female robot is given the appearance of a human woman from the working class, which toils in hellish conditions. While human Maria predicts the classes will unite in peace, her sexualised robotic counterpart incites a violent, destructive revolution.

A decade later, Lester del Rey's short story *Helen O'Loy* countered mechanical femme fatales like the robotic Maria with the synthetic housewife Helen, a domestic machine that gains emotions. Mid-century fiction favoured such bots over their more rebellious sisters. *The Twilight Zone* featured another mechanical wife as well as a perfect electric grandmother, and the Jetsons had reliable Rosie the maid.

But this domestic bliss wouldn't last. By 1972, Ira Levin was questioning what would happen to real women if robots could take their places. In his novel *The Stepford Wives*, Joanna is horrified



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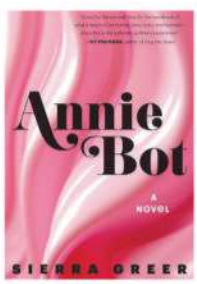

Alex Garland's 2015 film *Ex Machina* (above) and Sierra Greer's *Annie Bot* (below) follow a long tradition of female robots

"By 1972, Ira Levin was questioning what would happen to real women if robots could take their places"

to learn the men in her town have been killing their opinionated wives and replacing them with agreeable mechanical replicas.

Over the following decades, the *Terminator* and *Matrix* franchises tapped into those anxieties about tech replacing humans, which have ebbed and flowed since the industrial revolution. When jobs lost to machines are domestic, however, not all women would mind outsourcing them. Iain Reid's 2018 novel *Foe* culminates with a woman deserting her human husband and leaving a robotic replica in her place.

Two much more influential artificial women also appeared in the 2010s. In 2013's *Her*, a man falls for an AI called Samantha, but this makes him less able to relate to real women. In 2014's *Ex Machina*, an abusive inventor asks employee Caleb to assess his robot Ava. After Caleb develops feelings for Ava, she manipulates him to escape her creator. Samantha and Ava aren't evil, but they do look out for their own best interests – and these films explore what happens to the men around them when they do.

More recent work focuses on the artificial women themselves. In *Annie Bot*, Annie narrates her own story, putting the emphasis on her emotional development rather than her owner's. Greer demonstrates that, if a bot is a metaphorical woman, then it is also a person who deserves to live her own life. Similarly, this year's film *Companion* centres the experience of sex robot Iris – although her journey to freedom is less nuanced and more violent than Annie's.

But what happens to these artificial women – Samantha and Ava, Annie and Iris – once they free themselves? Where do they go next? That's up to the writers of the future. ▮

Our favourite robots

From Data and Deckard to WALL-E and BB8, ***New Scientist* staff** pick the greatest robots from books, films and TV series

Marvin the Paranoid Android, *The Hitchhiker's Guide to the Galaxy* series by Douglas Adams (1979)

Marvin is a Sirius Cybernetics Corporation prototype of GPP (Genuine People Personalities) tech. In truth, he shows little sign of paranoia, but he is certainly depressed, and no wonder: a robot with a brain the size of a planet destined for subservience. He did lend his name to one of Radiohead's finest songs, which might have cheered him up a bit.
Matthew Sparkes

BB8, *Star Wars: The Force Awakens* (2015)

When I think of *Star Wars*, the first droid that comes to mind is the one I favoured in my childhood: R2D2. Which is why I was a little unsure when BB8 blasted onto the scene in the final trilogy like a soccer ball from hell. But this lil' guy won me over with its charm, humour and that incredible, reckless speed. If I were a robot, I would want to be BB8.
Chelsea Whyte

Data, *Star Trek: The Next Generation* (1987)

Data, the second officer of the USS Enterprise, is one of television's most interesting androids. He is sentient and self-aware, he has romantic affairs and he grapples with his origin. Through Data, *Star Trek* delivers some of its most poignant punchlines about

humanity, empathy and the limits of cold rationality.
Karmela Padavic-Callaghan

Deckard, *Blade Runner* (1982)

Choosing Deckard for this list caused uproar in the *New Scientist* office. "He's human!" said my colleagues. Ridley Scott disagrees, describing him as "a replicant". Whether he dreams of electric sheep or not, the question his character raises about the nature of humanity is why I love this particular blade runner.
Matt Hambly

WALL-E, *WALL-E* (2008)

We probably shouldn't anthropomorphise robots, but who can blame us when

looking at the sad, binocular-shaped eyes of WALL-E, the adorable robot on tank-treads tasked with cleaning up a future polluted Earth? Cuteness aside, this robot is heroic too, saving humanity from aimlessly roaming outer space.
Alex Wilkins

Sonny, *I, Robot* (2004)

"You are just a machine, an imitation of life. Can a robot write a symphony? Can a robot turn a canvas into a beautiful masterpiece?" asks the detective. "Can you?" responds Sonny, the main robot character in the film *I, Robot*. It is one of the best moments in the movie, and these kind of comebacks are what make Sonny such a great character.
Michael Le Page

Ash, *Alien* (1979)

The real monster in *Alien* isn't the xenomorph – it is amoral corporate greed. Carrying out

the company's prime directive is android Ash (Ian Holm), whose admiration for the eponymous alien horrifies his expendable crewmates. Ash isn't self-aware so much as he is terrifyingly single-minded in his programming: results, no matter the human cost.
Kelsey Hayes

Hedonism Bot, *Futurama* (1999)

The origin of the term "robot" is *robota*, Czech for "forced labour". But Hedonism Bot is no one's slave. He exists not to toil for humanity, nor to serve

the will of an inventor. No, he exists to experience life at its most pleasurable by spreading chocolate icing on his rotund metal belly. For that, he is a god amongst bots.
Jacklin Kwan

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AJ PICS/ALAMY; MOVIESTORE COLLECTION LTD/ALAMY; CREDIT: SCREEN PROD/ALAMY; HULU

The sci-fi column

Bitter ends In the late 1800s, a feud breaks out between rival magicians who both claim they can teleport. Can either of them really do it, or is it all an illusion? Either way, the newly republished novel *The Prestige* is extraordinary, says **Emily H. Wilson**

Emily H. Wilson is a former editor of *New Scientist* and the author of the *Sumerians* trilogy, set in ancient Mesopotamia. The final novel in the series, *Ninshubar*, is out in August. You can find her at emilyhwilson.com, or follow her on X @emilyhwilson and Instagram @emilyhwilson1

Book
The Prestige
Christopher Priest
Tor Essentials, available in the UK and the US

Emily also recommends...

Book
The War of the Worlds
H.G. Wells
Various publishers
Christopher Priest was vice president of the H.G. Wells Society, so it seems fitting to recommend reading (or, for many of you, rereading) The War of the Worlds*, first published in 1898. The book is, in so many ways, sensationally modern. It is classic science fiction, and yet science fiction didn't exist then. But I also recommend it simply because it is a marvellous period piece that bears revisiting.*

Al PICS/ALAMY

Angier (Hugh Jackman) in the film version of *The Prestige*

THE PRESTIGE is probably best known from its 2006 film adaptation, directed by Christopher Nolan, fresh from the success of *Batman Begins*. The book it is based on, however, has devoted fans, and is often hailed as a literary masterpiece.

I didn't read the book until recently simply because I knew it to be about stage magic. Lots of people claim to enjoy an evening in the company of a magician, but I would rather do my taxes, or perhaps clean toilets. There was no way I was going to read a book about feuding stage magicians, set in the late 1800s.

However, when I met science-fiction writer Adam Roberts last year, I asked him to list some of his favourite sci-fi writers, and he at once named Christopher Priest, firmly recommending *The Prestige*, regardless of any feelings one might have about stage magic.

So that was my first reason to dive in, white gloves and top hats be damned. Then there is the fact that Tor has republished the novel, 30 years after it first appeared, with a new introduction by John Clute. (Priest died last year.)

And so to the book, which is about two different but apparently very similar stage tricks and how they are done. Our first hero (I use the word loosely) is the magician Alfred Borden, the creator of a trick called The Transported Man. In short, it involves Borden stepping into a booth on one side of the stage and instantly reappearing in another booth on the other side to rapturous applause from the audience.

> **"If you like complicated, beautifully designed puzzle-mysteries, then this book is most certainly for you"**

However, Borden has an enemy called Rupert Angier. This rival is driven to distraction as he tries to work out how Borden does his transportation trick. Later, Angier develops his own magical masterwork, In a Flash, in which he appears to be instantly transported from inside a flashing machine to another part of the theatre.

Now it is Borden who can't work out how his rival's trick is being done, and he is the one driven close to madness by his attempts to crack the mystery. The terrible feud ends up with consequences that will echo down the generations, which is why Borden and Angier share their role as narrators with two of their descendants.

The novel is a real page-turner. It drags you forwards much as a magician drags an audience along – because you really, really want to know how the tricks are done. But it is also far cleverer than it first appears.

I haven't yet tried this, but I rather think you could read the different sections in almost any order and still find it both interesting and comprehensible. That is to say, it is marvellously, ornately constructed.

As for its genre, it won a World Fantasy Award when it was first published, but it has science and a real scientist (the inventor Nikola Tesla) in it, and these days it is generally described as sci-fi. The vibe of the book is a bit gothic and a bit steampunk, and the style is studiously old fashioned, as befits a period piece.

So if you like complicated, beautifully designed puzzle-mysteries, then this book is most certainly for you. It is a triumph of both plotting and well-managed suspense. I now look forward to watching Nolan's cinematic version. Apparently, it is very different from the book, but Priest himself applauded the film version and thought that Nolan had done extremely well with it. ▮

Editor's pick

Reasons to doubt that space-time remembers

21 June, p 32

From Dan Kacsir, Indianapolis, US

Florian Neukart argues that a form of memory is "baked into" cells of space-time in such a way that is more or less permanent. This seems to imply that those cells are of the one-and-done variety. They can't be reused and overwritten, per se. That also implies there is an unlimited supply of new, unused cells available everywhere, just waiting to soak up new information.

Neither of those concepts fits well with our current understanding of how reality works. Neukart also talks of a paradox concerning the destruction of information, but there is no paradox. If we ever show that information can be destroyed, it just means that the belief that it couldn't was wrong!

Shocking difference in static electricity effects

5 July, p 34

From Maggie Cobbett, Ripon, North Yorkshire, UK

I learned a lot from your article on static electricity, but not why my husband has always been more affected by it than me. For example, there used to be a department store called Schofields in Leeds, UK, that he avoided because touching the banisters on any of its staircases gave him a painful shock. I, on the other hand, never felt a thing.

Maybe this is why fasting diets work

21 June, p 40

From Malcolm Hunter, Leicester, UK

In your look at the small intestine, you mention that overnight fasting causes the valve between its last section, the ileum, and the colon to close, leading to partially digested food being retained in the ileum. This results in a surge in microbial numbers and in the production of short-chain fatty acids, created by fermentation of fibre, that help shield the ileum's relatively thin lining from penetration by bacteria, cutting the risk of inflammation.

I wonder if an extended version of this occurs in intermittent fasting, where food is consumed during a very restricted period each day. Could this possibly explain some of its health benefits?

Why some believe in the anthropic principle

28 June, p 32

From Bryn Glover, Kirkby Malzeard, North Yorkshire, UK

You seem to have omitted the religious connotation usually associated with the "strong" anthropic principle. Those who believe in these things tend to assert that, as the universe was clearly designed to such an exquisite degree to permit life, it therefore follows that there must have been an omniscient designer.

Weebles would be just right for wobbly landing

5 July, p 11

From Peter Waller, Bristol, UK

I can't see that self-righting shape being of use in re-orienting moon landers. It would work only on a smooth and level surface. A design reminiscent of Weebles (self-righting toys) would be better. A weighted sphere floating in oil in a hollow sphere would be better still.

Da Vinci's flying machine has already taken to the air

5 July, p 18

From Hilda Beaumont, Brighton, East Sussex, UK

I was interested in your piece on Leonardo da Vinci's "aerial screw" design for a helicopter. The story focused on theoretical modelling showing it could have flown with modern materials and motors. Readers might be interested to learn that in 2022, Austin Prete at the University of Maryland developed a quadcopter in which each rotor was based on da Vinci's design. It could take off, fly in different directions and land.

Questions over AMOC geoengineering idea

5 July, p 11

From Richard Jefferys, Berkhamsted, Hertfordshire, UK

The idea you report on to possibly reinforce the vital AMOC ocean current in the Atlantic raises a question: could this only be done using sailing ships or kites? The problem is that a standard ship's propellers push it along by creating a stream of water in the opposite direction. Adding northwards momentum to AMOC by dragging parachutes through the water would seem to be countered by momentum added in the opposite direction from propellers.

More advice on tick bites and their aftermath

21 June, p 36

From Catherine West, Sydenham, Ontario, Canada

It was great to see your article on ticks, as I live in a hotbed area. I can add some more advice on avoiding bites. Spray insect repellent on your outer clothing, especially on socks pulled up over your trousers. Remove all outer clothing after going for a walk and either leave it outside or put it in a hot dryer for 10 minutes – even better, follow that with a shower or swim. Ticks wander around clothing and your body for many hours before settling on a place to bite.

Also be aware that dogs are tick magnets. They may be vaccinated against Lyme disease where I live, but they bring ticks inside that bite people. We are counting the days until we have a vaccine for people.

From Rebecca Libauskas, PETA Foundation, Norfolk, Virginia, US

Your story mentions that lone star ticks are spreading and are triggering allergies in people to red meat. Perhaps becoming allergic to animal-derived ingredients is a blessing. Many folks know they should go vegan, and itching and blotches can be powerful incentives. PETA published *The Lone Star Tick Cookbook: Easy, tasty, vegan bites* to help.

Lost ancient humans may hold a message for Mars

5 July, p 30

From Michael Paine, Sydney, Australia

The fate of small, isolated bands of ancient *Homo sapiens* who died out during harsh conditions as they tried to establish a presence in Europe millennia ago reminded me of proposals for colonies on Mars. It seems any foothold there would need a continuous resupply of people, as well as essential supplies, to keep the population dynamic and viable.

Is the mystery of Yeti and Bigfoot solved?

28 June, p 10

From Michael Zehse, London, UK

So new research finds Denisovans had very impressive physiques. Isn't this proof that sightings of abominable snowpeople and the like are, in fact, remnants of Denisovan communities living happy, untroubled lives away from so-called civilisation?

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For the record

Lori Marino at New York University featured in our story on orca gifts (12 July, p 19).

Backdoor to reality

Our search for new particles has been fruitless so far, but they might be hiding in a tiny slice of reality we are only just starting to glimpse, says particle physicist **Harry Cliff**

IT HAS been 15 years since the Large Hadron Collider (LHC) started smashing particles together. Since then, I have been one among thousands of researchers scouring its collisions for evidence of new physics that could explain mysteries like dark matter or the existence of matter in the universe. In 2012, the LHC uncovered the Higgs boson, securing the foundations of the standard model – our current best theory of fundamental particles and their workings. However, despite high hopes, it has yet to reveal new physics.

That isn't necessarily cause for despair. The LHC could be generating new particles right now that are escaping our notice due to them being exceptionally rare, hard to detect or superbly camouflaged amid the collision debris. If so, a major upgrade to the LHC planned for the end of this decade may yet reveal them.

Nevertheless, we must also confront a more troubling explanation: that the particles we seek are beyond the reach of the world's biggest collider. In that case, we may have to wait decades for a more powerful successor – if one is ever built, that is.

But Andrzej Buras, a theorist at the Technical University of Munich, Germany, isn't prepared to wait that long. At the age of 78, he is rallying the field behind the idea that we can crack open a backdoor to a realm far beyond the LHC's reach. His mission is to get to what he calls the zeptouniverse – a world that exists at distances of 10^{-21} metres, or a sextillionth of a metre – because it is here that we suspect the long-sought new particles may be hiding. What's exciting me, for one, is that we have recently begun to knock at this door.

The standard model is the closest we have come to a theory of everything, describing all the known fundamental particles and forces, with the exception of gravity. It has passed every experimental test we have thrown at it, with somewhat maddening accuracy. Maddening, because we know that the standard model is incomplete.

Glaringly, it can't account for the existence of dark matter, an invisible substance whose gravitational pull shapes the cosmos. It also offers no explanation for the peculiar patterns we see in fundamental particles, which hint at some deeper structure. The particles of matter seem to come in three successively heavy "generations", for example (see "The ingredients of reality", page 32), and we don't know why. Perhaps worst of all, it suggests that all matter should have been annihilated with its mirror image, antimatter, in the first microsecond of the big bang. Clearly, any theory that predicts the non-existence of the universe is in trouble.

This is why theorists are confident that the standard model is far from the final word on particle physics and that there must still be new fundamental particles to be found. And with the LHC – which is based at the CERN particle physics laboratory near Geneva in Switzerland – so far drawing a blank, we are determined to find fresh ways to probe for these new particles. Which is what makes this backdoor so tantalising.

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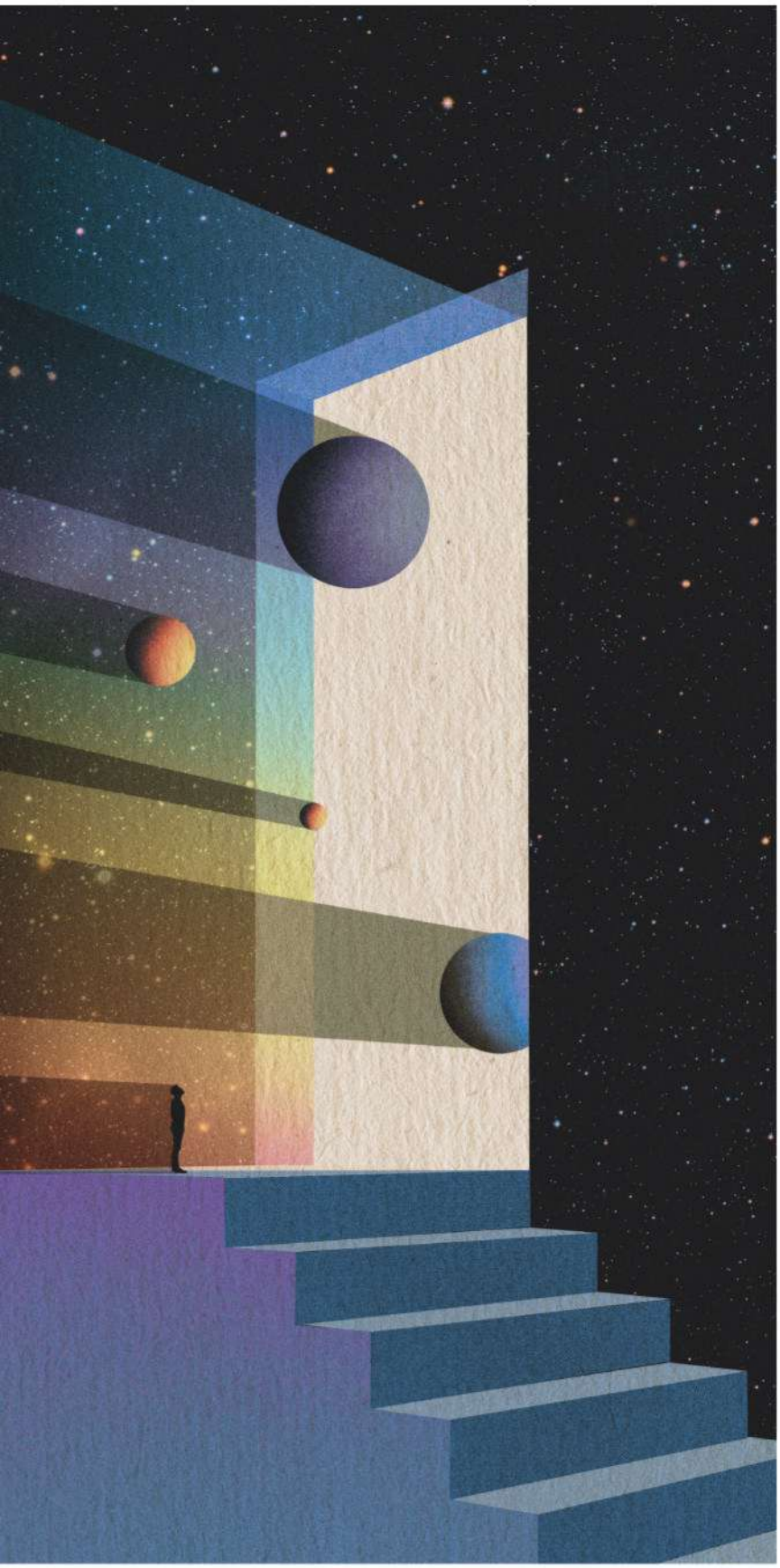


To understand why it exists and how we might step through it, we must get to grips with a few particle physics essentials. The first is that, as well as probing high collision energies, colliders simultaneously explore minuscule distances.

The LHC's reach is typically described in terms of the maximum energy to which it can accelerate particles: the more energy that goes into a collision, the more massive (or heavier) the new particles it can create, with energy converted into mass. However, another way to think about a collider is as a supersized microscope capable of probing the fundamental components of reality at extremely short distance scales.

This is because, in the realm of particles, there is an inverse relationship between energy and distance. Quantum theory shows us that electrons or protons, say, simultaneously behave like waves. When particles are accelerated to high energies, their wavelengths grow shorter and shorter, meaning they become probes that allow us to "see" down to scales far smaller than an atom.

The LHC accelerates protons to just under 7 trillion electronvolts, which gives it access down to distances of around 50 zeptometres. That is an unfathomably short distance, some

"Any theory that predicts the non-existence of the universe is in trouble"

tens of billions of times smaller than an atom (see "Down in the zeptouniverse", page 33). The problem is that if new physics is hiding at distances shorter than the LHC's resolution, then we won't see it – at least not directly.

The second thing you need to know is that very massive particles that exist at smaller distance scales can influence the behaviour of lighter particles at larger scales. This is because, as quantum field theory tells us, particles aren't themselves fundamental but are vibrations in ever-present quantum fields – invisible, fluid-like objects that fill the entire universe. In this picture, particles are like ripples in a cosmic ocean, and even when there are no waves in that ocean – that is, no particles – the quantum field associated with the particle is always present.

So, even if a new particle might be too small for the LHC to resolve, its quantum field can ›

still have a lingering influence at longer distances, affecting how larger-scale particles behave. Crucially, this means that the precise measurements of the particles we routinely produce in existing accelerators can reveal the influence of new particles that lie beyond our direct sight.

The key is to choose a process involving known particles that we believe to be especially sensitive to the existence of new quantum fields. Typically, these are decays where a heavier particle created in a collision transforms into some lighter particles. Most unstable particles can decay in a wide variety of different ways, with some decays more likely than others. It is the rarest of these decays, predicted to happen less than a few times per billion particles, that are the most sensitive probes of new quantum fields. As such, they could be our route to whatever lies beyond the standard model.

The idea is simple enough. First, theorists make precise predictions for how often one of these rare decays should occur, according to the standard model. Then, experimentalists make the most precise measurements we can of those decay rates using data from the LHC and other accelerators. Any significant discrepancies between theory and experiment are indirect evidence of new particles.

In practice, studying decay rates with the kind of accuracy required is exceedingly fiddly. What is particularly tricky is dealing with the effect of quantum chromodynamics (QCD), the theory that describes the interactions between the quarks that comprise the nuclei of atoms, and gluons, the carriers of the strong nuclear force that binds them. The effects of QCD are notoriously difficult to calculate, making predictions of many rare decays involving quarks unreliable. If we choose our decay channels wisely, however, we can minimise this confounding effect and give ourselves a decent chance of detecting echoes from the zeptouniverse.

To that end, Buras has worked with Elena Venturini, now at the International School for Advanced Studies in Trieste, Italy, to draw up a list of prime targets for investigation, which they dub the "magnificent seven". They are all extremely rare decays of particles containing exotic types of quark: strange or bottom quarks.

These decays are particularly rare because getting from the initial particle to the decay products in the standard model requires a complicated mixture of several extremely massive intermediate particles whose characteristic length scales are much shorter than either the initial or final-state particles. As a result, they stand out for their potential to allow us to observe new physics within the decade – and experimental efforts to do so are already under way around the world.

"We have started to crack open the door – now we need to walk through"

Several of the magnificent seven are decays of B mesons, composite particles made from different kinds of quark. I am co-leading a team at the LHCb experiment to study the decays of B mesons into a muon and an anti-muon. Muons are heavier versions of electrons and don't interact directly with quarks or gluons, making these decays theoretically "clean". They are also exceptionally rare, with rates of a few parts per billion or less.

While previous studies at LHCb and at our two friendly competitor LHC experiments, known as CMS and ATLAS, agree with the standard model so far, there is still a chance that the effects of new physics will emerge as we increase the precision of our measurements. LHCb recently underwent a major upgrade to boost the rate at which we collect data by a factor of five. We are now rapidly accumulating vast new samples of B mesons created by collisions. Soon, this will allow for significantly more precise measurements than we have been able to make so far, with the influence of new particles potentially appearing as our statistical uncertainties shrink.

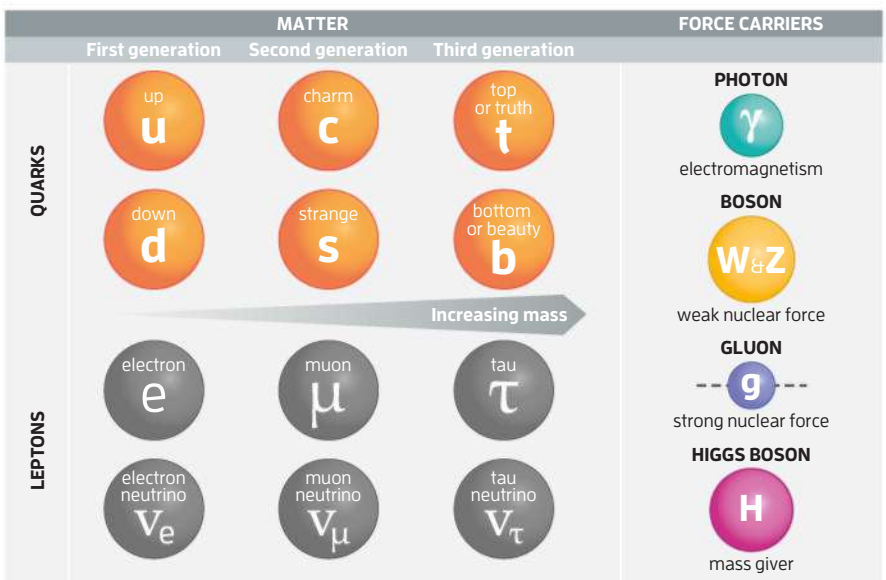
On the other side of the world in 2023, the Belle II experiment in Japan produced the first evidence for another of the magnificent seven: the decay of a B meson into a particle called a kaon and two neutrinos. Like the muon decays we measure at LHCb, these decays are also very clean, this time for reasons to do with the presence of the neutrinos.

As with muons at the LHCb, the presence of neutrinos in the final state reduces those irritating theoretical uncertainties. Intriguingly, the decay rate Belle II measured is somewhat above that predicted by the standard model, though the evidence is still too slight for any champagne to be uncorked just yet.

The processes that could take us deepest into the zeptouniverse, however, are decays of particles containing strange quarks. In particular, Buras and Venturini highlight three decays of kaons in their magnificent

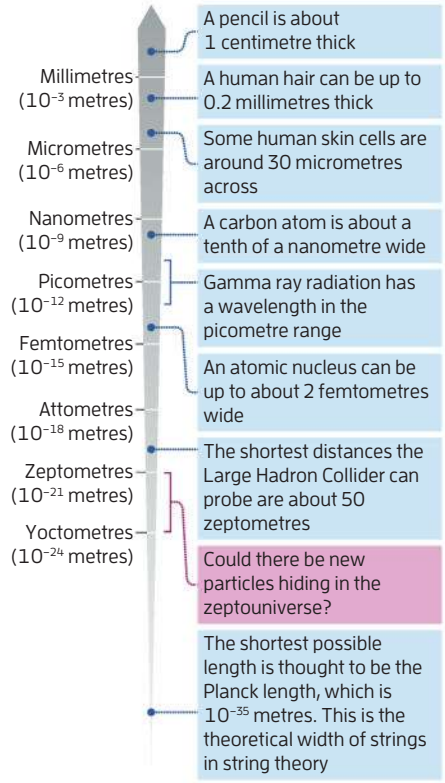
The ingredients of reality

The standard model of particle physics lists the particles that constitute matter and the fundamental forces



Down in the zeptouniverse

Physicists have found a way to explore an extremely tiny part of reality called the zeptouniverse. Here is how to grasp just how small it is


Millimetres (10^{-3} metres)
A pencil is about 1 centimetre thick
A human hair can be up to 0.2 millimetres thick
Micrometres (10^{-6} metres)
Some human skin cells are around 30 micrometres across
Nanometres (10^{-9} metres)
A carbon atom is about a tenth of a nanometre wide
Picometres (10^{-12} metres)
Gamma ray radiation has a wavelength in the picometre range
Femtometres (10^{-15} metres)
An atomic nucleus can be up to about 2 femtometres wide
Attometres (10^{-18} metres)
The shortest distances the Large Hadron Collider can probe are about 50 zeptometres
Zeptometres (10^{-21} metres)
Could there be new particles hiding in the zeptouniverse?
Yoctometres (10^{-24} metres)
The shortest possible length is thought to be the Planck length, which is 10^{-35} metres. This is the theoretical width of strings in string theory

MAXIMILIEN BRICE/CERN

The NA62 experiment at CERN may just bag evidence of particles in the zeptouniverse

seven, which contain a strange quark and an antiquark. Between them, these rare decays probe physics at distances and energy scales far beyond even the most ambitious planned future collider. And here we already have some tantalising discrepancies between what theorists expect and what experimentalists measure.

They come from another, smaller-scale experiment at CERN known as NA62, where protons are slammed into a target, producing a shower of exotic particles, including kaons. The job of the NA62 detector, which has been running since 2015, is to find the extremely rare case where a kaon decays into another charged particle called a pion, plus two neutrinos. Neutrinos are famously elusive, as they hardly interact with ordinary matter and so are almost completely undetectable. NA62 therefore looks for kaons that appear to have transformed into pions and nothing else, while crucially eliminating any other processes where the final-state particles just happen to have been missed.

In September last year, NA62 announced the first-ever observation of this incredibly rare decay, which occurs roughly once for every 10 billion kaons. Not only is it the rarest particle decay we have ever seen, but the measured decay rate was also about 50 per cent higher than the standard model prediction. Physicist Cristina Lazzeroni at the University of Birmingham, UK, a former spokesperson for the experiment, told me this discovery was a thrilling moment. But it is still too early to party, as the uncertainty surrounding the measurement is far too large for us to be confident that it represents bona fide new physics and not a statistical blip.

The study of this decay in particular does mean we have started to crack open the door to the zeptouniverse, though. What we need to do now is walk through and start having a proper poke around. The way to do that is to gather more precise measurements of this type of decay, and the good news is that NA62 will continue collecting data for another couple of years. Less fortunately, the hall it occupies will then need to be cleared to make way for a new, recently approved experiment. While the extra data that will be gathered before then may strengthen the current weak hint of new physics, it is unlikely to be conclusive.

Expedition planning

What's more, much to the dismay of Buras, the High Intensity Kaon Experiment that could have extended NA62's work wasn't approved by CERN. This means our best hope lies with the KOTO experiment at J-PARC in Japan, where physicists are conducting a parallel search for a second rare kaon decay. They have yet to see a signal, but there is more data to come.

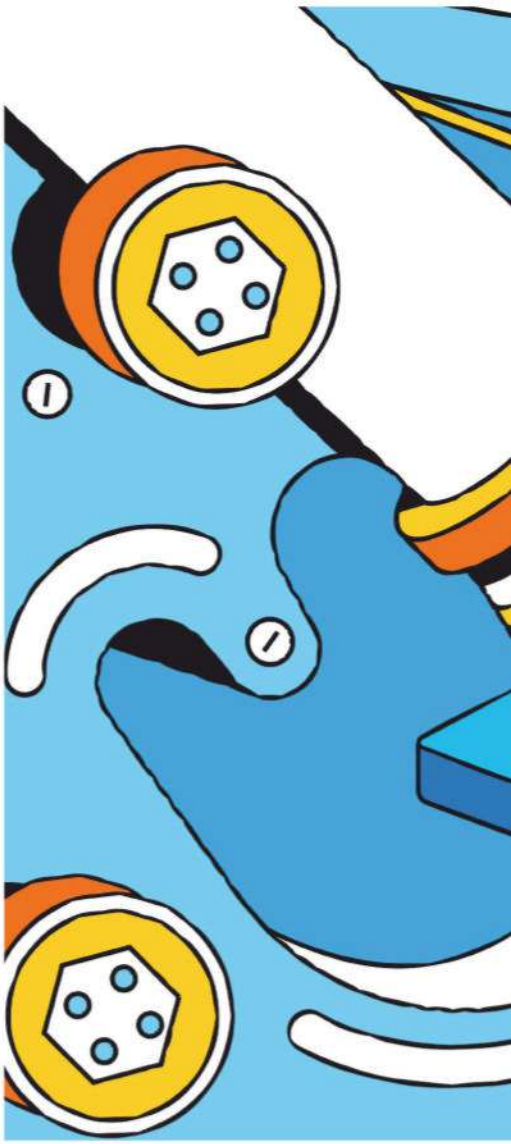
Where does all this leave us? When I chatted to Buras recently, he told me he was frustrated. Though he remains in good health for now, he isn't a young man and – understandably – wants to see progress swiftly. There are reasons to be optimistic that we will see some new physics in the coming years. With the LHCb upgrade recording a torrent of new data, and further measurements expected from experiments both at CERN and in Japan, the current hints may well turn into something more solid.

Looking further into the future, a second major upgrade of LHCb now being planned will boost the rate at which data is recorded by an order of magnitude. Once it comes online in the 2030s, this third incarnation of the experiment should ensure that we really can make good on Buras's vision of a proper expedition into the zeptouniverse – and find whatever exotic particles might be hiding down there.

Such signposts of new physics can't come soon enough. Particle physics is at an inflection point, as the European scientific community lays out its long-term vision for the LHC's successor. This next machine is essential if we are to continue to explore the most fundamental workings of nature, but building it will be a monumental task – scientifically, technically and, perhaps most crucially, politically.

The cost and scale of the next collider will dwarf even the LHC, pushing the limits of what can be achieved in a single scientific project. So, some clear signs that new physics really is waiting for us in the zeptouniverse would make the case for a collider that can probe it directly all the more compelling. ▮

Harry Cliff is a particle physicist at the University of Cambridge



Regrow your own teeth

Lose a tooth today and your options are limited to artificial replacements like implants. Soon there could be a better way, finds **Michael Marshall**

MANY of us will lose an adult tooth in our lifetime, whether through disease or misadventure – a punch that landed, a skateboarding trick that didn't, say. And if you join their ranks, which include the nearly 178 million adults in the US who have lost at least one tooth, your options are pretty much the same as they have been for millennia: artificial replacement.

Dental technology has moved on since the ancient Etruscans fashioned fake teeth from oxen bones, but not much. The metal implants we use today tend to fail over time, causing significant pain when they do. But what if there were another way? What if, instead of implants and dentures, you could regrow lost teeth?

That's the question a journalist asked Paul Sharpe about 20 years ago, changing the shape and direction of his research entirely. Sharpe, a craniofacial biologist at King's College London, and his colleagues had been studying how a handful of cells become a mouthful of teeth for years. At the time, the field of tissue engineering was fairly well-established, in research if not in clinical practice. Regrowing teeth would be a natural extension. So Sharpe started thinking: "If we wanted to regrow a tooth, what would we need to do?"

It turns out there are a few ways to successfully regrow a lost tooth. Sharpe and his team spent around two decades figuring out one mechanism, while researchers at Tufts University in Massachusetts pursued a different approach. Both have seen positive results in the lab. And right now, scientists in Japan are conducting clinical trials for a drug that promises to grow teeth in a person's mouth more or less from scratch.

This could be the future of dentistry: instead of lifeless metal implants, we could have new living teeth that work and feel just like the old ones. Technically, it's perfectly feasible. So why hasn't it happened?

Almost 7 per cent of people over the age of 20 worldwide have lost all their teeth, a figure that jumps to as high as 23 per cent in those over the age of 60, according to the World Health Organization. In the UK, 5 per cent of people aged 16 or over don't have any of their natural teeth. There are, of course, dramatic ways to lose teeth, but mostly it is caused by tooth decay – dental cavities that occur when bacteria living on the teeth produce acids that dissolve the hard parts. And for now, if you lose a tooth as an adult, you can't grow a new one.

"The most common treatment these days is to have a titanium implant," says orthodontist

TIM ALEXANDER

Pamela Yelick at Tufts University. In the 1950s, physiologist Per-Ingvar Brånemark inserted a titanium chamber into a rabbit's leg to observe blood flow, only to find months later that he couldn't remove it because the bone tissue had fused to it. Brånemark had accidentally discovered that titanium can bond to bone. This made it ideal for replacement teeth, which must be inserted into the jaw.

Titanium implants are now standard, but they have their downsides. Because they are made of metal, they don't generate any sensation. "You can't feel it when you chew with it," says Yelick.

Unlike implants, natural teeth have ligaments attaching them to the bone to absorb some of the force of chewing, reducing stress on the jaw. "When you have an implant, you don't have anything to dampen those forces of chewing," says Yelick. The constant pounding of chewing can cause the bone around the implant to break down, leading to inflammation and pain.

A living tooth, however, would last longer and be stronger. It would feel like the real thing, complete with nerve endings, and would be less likely to cause infection or be rejected. "The ultimate goal," says Sharpe, "is to replace a lost tooth with a biological tooth that's completely normal."

But to figure out how to make a replacement tooth, you first have to understand how we get teeth in the first place. Making a tooth requires the interaction of two types of cell: dental epithelial cells form the hard enamel that coats our teeth, while dental mesenchymal cells give rise to other parts of the tooth, including the dentine that sits below the enamel and the soft pulp at the tooth's centre.

The good news is that it is possible to obtain dental mesenchymal cells from the pulp of an adult tooth, say from a wisdom tooth that has been extracted. The bad news is that dental epithelial cells are only really present in young children. "Those cells are virtually gone once your adult tooth erupts," says Yelick.

There is a further problem: even if you could get hold of dental epithelial cells from somewhere, they need the correct conditions if they are to grow into something resembling a tooth.

Inspired by tissue engineering, Yelick and her colleagues attempted to solve this by making a scaffold – in this case, a bundle of fluffy fibres a bit like a cotton ball – on which cells could sit and grow into a tissue. "You have this scaffold, and you can seed it with cells, ›

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and you can add growth factors," says Yelick.

It worked: they obtained the two cell types from the molars of pigs and placed them on scaffolds made of polyester, implanting these little structures into the mouths of rats. After 20 to 30 weeks, they had teeth – or rather "recognisable tooth structures" – containing both dentine and enamel. "They would form these little, tiny, beautiful tooth crowns," says Yelick.

Tooth scaffolds

That was in 2002. She and her colleagues have been improving their process ever since. In their most recent paper, published in 2024, Yelick and Weibo Zhang, also at Tufts University, used an improved scaffold: tooth buds from pigs, stripped of all their cells. They then seeded these with a mix of dental cells – some from humans and some from pigs – and introduced the resulting bioengineered structures into the mouths of pigs. After two to four months, the structures developed into "tooth-like tissues", a model, says Yelick, "for what eventually we might be able to do in people."

Sharpe, however, is sceptical that teeth grown on scaffolds like this would ever replicate all the complicated, three-dimensional structure of normal teeth. "You've got two types of hard tissue that are made by different cells that are unique in the body," he says. "They're found nowhere else outside teeth." That said, he wants Yelick to continue her work, "because I might be wrong".

While Yelick perfects tooth scaffolding, others are working on a different approach – trying to trick adult cells into behaving like embryonic stem cells.

All the different cell types in our bodies started as embryonic stem cells. The most flexible ones, which can form any cell type, are called pluripotent stem cells. In the 2000s, biologists led by Shinya Yamanaka, then at Kyoto University in Japan, showed that adult cells could be "reprogrammed" to behave like pluripotent stem cells by adding a few transcription genes, now commonly referred to as Yamanaka factors. These "induced pluripotent stem cells" (iPSCs) could then be used to make any desired cell type. Ever since, researchers have been trying to use iPSCs to grow replacement tissues and organs.

In theory, iPSCs would be ideal for growing new teeth. Many different types of cells from adult teeth have been converted to iPSCs, and as early as 2013, researchers in China showed that iPSCs could form tooth-like structures. A 2024 review argued that iPSCs could be used to repair damaged enamel. However, says Sharpe, unless the cost of creating and using iPSCs falls to below the cost of a dental implant – which in the UK can be around a couple of thousand pounds – iPSCs will probably never be used to regrow teeth. "It doesn't matter how good the science is," he says. "If it's too expensive to ever reach the market, it's never going to be worth doing in the first place."

So Sharpe and his colleagues took another approach: trying to persuade adult cells to grow into teeth. "That's a big task, because you are trying to get adult cells to behave like embryonic cells," he says. "You're making them do something they wouldn't normally do."

When dental epithelial cells and dental mesenchymal cells combine to form a tooth, they do so by sending a complicated series of chemical signals back and forth among themselves. For this to work, at least one of the cell types needs to be an embryonic cell – only they send the right signals to start the process. "That is a big, big stumbling block," says Sharpe.

To get around this, Sharpe and his team have meticulously mapped out the sequence of chemical signals the cells send during tooth development.

Earlier this year, they described an atlas of the cells involved in the various stages of tooth development and found a way to boost the strength of the chemical signals. "The challenge now is to introduce those signals to that cell combination and get those two adult populations to think one of them is doing the right things to start the process off and make a tooth," says Sharpe.

Children can grow a set of adult teeth because they are born with the right kinds of cells. Afterwards, we lose the ability.

EYE OF SCIENCE/SCIENCE PHOTO LIBRARY

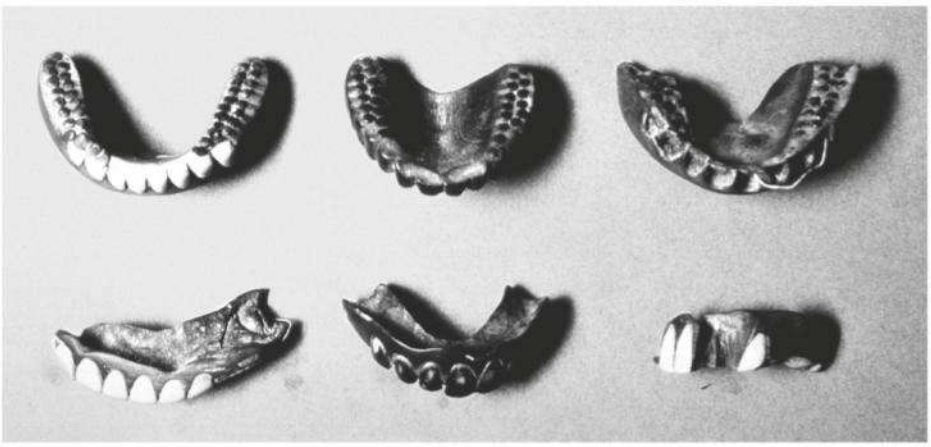
PHOTOALTO/ANNE-SOPHIE BOST/GETTY IMAGES

The appeal of this approach is that it essentially duplicates what happens in normal tooth development: "Our body knows how to make teeth," he says. Persuading adult cells to do that is difficult, however.

The reality is that, after more than 20 years of research, neither method of tooth regrowth has been used in a human clinical trial, much less a dentist's chair. This is partly because dentistry is relatively underfunded, especially compared with other areas of medicine like cancer or heart disease. "You can live without your teeth, but you can't live without a heart or a brain," says Yelick.

But there may be another approach on

Early tooth replacements included wooden dentures, such as these from early 20th-century Japan



HUM IMAGES/ALAMY

the horizon. Mary MacDougall at the University of British Columbia in Vancouver started trying to regrow teeth cells and structures 20 years ago. "I remember all my interviews back then, and five to 10 years was always going to be the time frame," she says ruefully. As the sheer complexity of tooth development became clear, she realised that was over-optimistic.

Today, however, MacDougall is excited again because there are hints that people might be able to grow new teeth without the involvement of stem cells.

MacDougall was involved in research that laid the groundwork for a new approach that works by mimicking the biology underlying a rare genetic condition called cleidocranial dysplasia. People with it often have no collar bones or severely reduced ones, and many grow extra teeth. Cleidocranial dysplasia is caused by mutations in a gene called *RUNX2*, which encodes a protein called Runt-related transcription factor 2 that is involved in the development of bones and teeth.

In 2016, MacDougall was a co-author on a study led by Katsu Takahashi at Kyoto University in Japan that looked at the function of *RUNX2*. Working with genetically modified mice, the researchers found that *RUNX2* works in tandem with another gene called *USAG-1* as master switches turning tooth development on and off. This explains why mutations in *RUNX2* can cause people with cleidocranial dysplasia to grow extra teeth – and why genetically modified mice in which *USAG-1* is deactivated also grow additional teeth.

Takahashi and his colleagues took the research a step further, proposing that it might be possible to trigger tooth regeneration by inhibiting *USAG-1*. In 2021, they studied mice with genetic abnormalities that stop their teeth from growing, finding that they could reverse this by triggering mutations that knocked out *USAG-1* or by giving the mice antibodies against the protein encoded by the gene. In a second study, they got the same result using RNA that targeted the *USAG-1* gene.

> "Our body knows how to make teeth, but persuading adult cells to do so is difficult"

Takahashi and his colleagues established a company called Toregem Biopharma to explore whether giving people antibodies against the protein *USAG-1* encodes could enable them to grow new teeth. (Takahashi and Toregem Biopharma didn't respond to requests for comment.) In 2024, they reported that they had developed such an antibody and successfully tested it in mice. Not long after, they announced the start of a phase I clinical trial, giving the medication to adult men with no significant health issues missing at least one tooth, to determine the safety and potential dosing of the drug.

If successful, the company plans to test the treatment in children aged between 2 and 7 with congenital edentulism, a genetic condition that keeps them from growing teeth. "A therapeutic for those individuals would be of great value," says MacDougall. Otherwise, "they're going to be wearing dentures the rest of their life", she says.

Treating such young children is easier because they still have their dental epithelial cells, says MacDougall, but it is unclear whether Takahashi's approach would ever be useful for adults who have lost teeth and lack dental epithelial cells. MacDougall suggests there might be a small number of stem cells left in the jaw, which could respond to the drug. Sharpe and others have doubts. For one thing, it could be difficult to control which teeth start growing, Sharpe points out. If a person is only missing one tooth, it would be bad to trigger the development of six.

Whether we can get around these issues should become clearer with trials. That will probably take a few years, although Toregem Biopharma has said it wants to bring the drug to market in 2030.

The answer to that journalist's question, however, the one that prodded Sharpe's research into an exciting new direction, is clear. The technical barriers to regrowing teeth have largely fallen – but the financial ones remain. Sharpe is concerned that the technology may never come to fruition because research funders, pharmaceutical companies and venture capitalists simply aren't interested. Toregem Biopharma might be an optimistic outlier. Researchers like Sharpe are "sitting on stuff that they know will work", he says, because they can't get funding for human clinical trials, let alone commercialisation.

Yelick, however, remains optimistic about regrowing teeth: "I do think that, within the next 10 years, we will have biological tooth replacements available." Maybe this time, it'll happen. ▮

Michael Marshall is a science writer based in Devon, UK

Burial rites

Claims that a small-brained hominin called *Homo naledi* buried its dead raise intriguing questions about why we engage in this practice, says **Colin Barras**

WESTEND61 GMBH/ALAMY

SOME people will tell you that *Homo naledi* was a small-brained hominin with some big thoughts. Two years ago, a team led by Lee Berger at the University of the Witwatersrand, South Africa, concluded that *H. naledi* – a species that lived around 335,000 to 245,000 years ago and had a brain about one-third the size of yours – invented a complex ritual that involved burying its dead in a deep and difficult-to-access cave chamber.

This idea didn't go down well: all four of the anonymous researchers asked to assess its merit were sceptical. But Berger and his colleagues were undeterred. Earlier this year, they published an updated version of their study, offering a deeper dive into the evidence they had gathered from the Rising Star cave system in South Africa. The approach paid off: two of the original reviewers agreed to reassess the science – and one was won over. "You rarely see that in peer review," says John Hawks at the University of Wisconsin-Madison, a member of Berger's team.

Many other researchers, however, are still wary. "I'm just not convinced by any of it," says Paul Pettitt at Durham University, UK. To appreciate why, it is necessary to explore how other ancient hominins interacted with the dead. Doing so can help us figure out which species carried out burials, how ancient the practice is and what it says about the minds and motivations of those doing it. Considering this also reveals why, if *H. naledi* really did bury its dead, that would fundamentally challenge our understanding of early hominin cognition and behaviour.

There is one archaeological site that has much in common with Rising Star: Sima de los Huesos (the "pit of bones") in northern Spain. There, researchers have uncovered the remains of 29 hominins, thought to be an ancestor of Neanderthals, at the bottom of a vertical shaft within a cave. The consensus is that the Sima hominins, who lived between 430,000 and 300,000 years ago, died elsewhere and that their bodies were then dropped into the pit. If so, this represents the oldest clear evidence for some sort of funerary behaviour.

Such an early date may seem surprising, but in context, it makes sense. We know that chimpanzees show an interest in dead group members, grooming their fur and even cleaning their teeth. "If we have chimpanzees behaving this way, then we might expect similar behaviour deep in our evolutionary past," says Pettitt.

However, the funerary behaviour on show at Sima appears more sophisticated than anything chimps do, says María Martinón-Torres at the National Human Evolution Research Centre (CENIEH) in Spain. "They have chosen a place to put the dead." What's more, the excavation also unearthed a stone hand axe, which is sometimes interpreted as a funerary offering – although it could simply have been in a pouch worn by one of the hominins found there, says Pettitt.

Such elaborate treatment of the dead may have been evolutionarily beneficial. At some point in prehistory – perhaps when brains reached a certain size – hominins must have become aware of their own mortality, says Pettitt. In a 2023 paper, he suggested that complex funerary behaviour might then have arisen to mitigate personal anxiety about death by bringing the community together when a group member died. This scenario could explain what happened at Sima, given that the average brain size of these hominins was 1237 cubic centimetres – only about 100 cubic centimetres less than the average modern human.

Violent deaths?

Others see something more sinister at Sima. Mary Stiner at the University of Arizona points out that many of the skeletons are from adolescents or young adults. "That's an age group in which individuals choose to take risks and are more vulnerable due to low experience," she says. Moreover, there are signs on the bones that some of the Sima hominins died violently. Stiner thinks the skeletons may represent youngsters who left their family group, strayed into hostile territory and came to a grisly end – their bodies tossed into the pit by their killers, perhaps to hide the evidence. But as Pettitt points out, that would require an unusually large number of adolescents making the same mistakes and meeting a similar fate.

For now, it is difficult to know exactly how to interpret the Sima site. Fortunately, more evidence may soon be available. Since 2021, Nohemi Sala at CENIEH and her colleagues have been exploring the archaeological record of funerary behaviour through a project known as DEATHREVOL. Sala says the research suggests that there are other similarly ancient sites in Europe that may preserve evidence of the same behaviour recorded at Sima – although she won't name them until the work is published. "There are four or five candidates to explore these patterns," she says. "It's more than just Sima."

Eventually, hominins like those at Sima ›

"If *Homo naledi* buried its dead, it would challenge our understanding of early hominin cognition"

Homo naledi lived in South Africa about 335,000 years ago and had a small brain

IMAGO/ALAMY

gave rise to the Neanderthals, who had different ways of treating the dead. Some of the clearest evidence for this comes from Shanidar cave, a site in northern Iraq where, since the mid-20th century, the remains of at least 10 Neanderthals have been discovered. The oldest dates back about 75,000 years, making it among the oldest known Neanderthal burials.

Another set of remains was pivotal to us recognising in the late 20th century that Neanderthals shared our humanity, because pollen around this individual's bones suggested that they had been buried with flowers. Today, while nobody doubts Neanderthals' humanity, few archaeologists buy the "flower burial" idea. Recent excavations at Shanidar point to an alternative explanation for the pollen. Chris Hunt at Liverpool John Moores University, UK, and his colleagues think the body may have been placed in the ground and then buried under a pile of brushwood rather than dirt. They note that some of the pollen around the skeleton comes from plants with prominent spikes, possibly added to deter scavengers.

Nevertheless, the Shanidar burials are revealing. One was of a man who managed to live with severe injuries to his face, shoulder and arm. Stiner is among several researchers who think he would have required help to do so, suggesting Neanderthals cared for and valued each other as individuals. If they did, then death wasn't merely the loss of a pair of hands for sourcing food; it was the loss of someone with a unique personality who would be missed – leading to a new motivation behind funerary behaviour. "These societies were bound by love and affection," says Stiner.

Five of the skeletons at Shanidar hint at something else. They were all buried in the same spot in the shadow of a prominent landmark – a 2-metre-high rock inside the cave – over the course of a few decades to a few millennia. Hunt and his colleagues think this might be a sign that Neanderthals tied meaning to landmarks in their environment. More speculatively, burying the dead here may even have played a role in legitimising the right of the living to the nearby land and its resources. Our species can have that sort of relationship with land, says Emma Pomeroy at the University of Cambridge, who was also involved in the recent excavations at Shanidar. "I think it's very interesting to think about whether Neanderthals had a similar attitude to the landscape."

Mysteries remain. A big one is why only a few of the Neanderthals who lived around Shanidar were buried in the cave. "If this was something that hominins did a lot, the caves would be chock-a-block with bodies," says Hawks. Evidence from elsewhere indicates that other Neanderthal deaths may have been honoured with different funerary treatments, including ritual cannibalism – but for some as-yet-unfathomable reason, very few Neanderthals ended up interred in the cave. Another question is whether Neanderthals devised the idea of burial themselves or learned it from our species, *Homo sapiens*, whom they met around the time of the Shanidar burials.

Grave goods

What we do know is that our species began burying its dead around 120,000 to 100,000 years ago. And some early *H. sapiens* burials appear to differ from those of Neanderthals by the inclusion of grave goods. For instance, a body in Qafzeh cave in Israel appears to have been buried with red deer antlers clasped to its chest – although other interpretations are possible. "Perhaps the antler was used to dig the grave and it's just a fortuitous association," says Pettitt.

We don't know how common early grave goods were, in part because human burials were so rare before 28,000 years ago. Neither do we know their exact significance, although in later burials they are generally seen as reflecting things like the status and occupation of the deceased.

Rare though they are, early human burials reveal intriguing signs of a pattern. In 2021, a team including Martinón-Torres and Michael Petraglia, now at Griffith University, Australia, described an excavation at Panga ya Saidi cave in Kenya in which they had unearthed the 78,000-year-old burial of a toddler they named Mtoto. The researchers noted that Mtoto is the earliest of three potential *H. sapiens* burials in Africa, which date to between 78,000 and 68,000 years ago. All three involved young children.

Childhood mortality was probably relatively high in these early communities, says Petraglia. "We don't have the evidence to say for sure, but we suspect so because childhood mortality is pretty high in hunter-gatherer

MATYAS REHAK/ALAMY

Shanidar cave in Iraq contains some of the oldest Neanderthal burials

UNIVERSAL HISTORY ARCHIVE/SHUTTERSTOCK

Was this early *Homo sapiens* buried with a red deer antler on purpose?

societies." Even so, some children's deaths might have been "particularly painful", says Martinón-Torres, motivating early communities to commemorate them with what was, at the time, an unusual funerary ritual: burial.

Pettitt has explored this idea. He distinguishes "good deaths", which usually occur in old age, from "bad deaths", which occur unexpectedly and often involve children. The latter may have provided an impetus for people to perform special funerary rites, he suggests, which might help explain burials like Mtoto's.

Another clue to the thinking of these Stone Age people comes from the fact that Panga ya Saidi cave was a place of human habitation on and off for thousands of years. This suggests a decision was made to inter Mtoto's small body in close proximity to the community's living space. "If you bury someone you love, in a way, you don't want them to go," says Martinón-Torres. Placing them in an easy-to-visit location may help maintain a close connection, she adds.

So, what does all this tell us about whether *H. naledi* buried its dead?

There are certainly echoes of other sites in Rising Star. The idea that, hundreds of thousands of years ago, hominins placed their dead deep inside a cave draws parallels with Sima de los Huesos. The suggestion that *H. naledi* repeatedly returned to the same site to inter bodies seems to mirror the situation at Shanidar cave. And the discovery of a crescent-shaped stone near the fossilised hand of one *H. naledi* skeleton – a possible grave good – looks like behaviour seen at sites like Qafzeh.

But the burial hypothesis also seems all wrong. The biggest stumbling block is the size of *H. naledi*'s brain, which, at an average of 513 cubic centimetres, was tiny. For a start, it raises doubts about whether individuals really were aware of their own mortality, inventing elaborate funerary rituals to come to terms with this revelation.

There is also no evidence yet that the species cared for its sick, a potential sign that group members were valued as individuals whose deaths were mourned. And although youngsters are overrepresented in the Rising Star cave – potentially consistent with Pettitt's "bad death" idea – the chamber in which the bones were found doesn't seem to be an easy-to-visit location that would allow the living to maintain a connection with the dead. "It's quite anomalous, but also fascinating," says Stiner.

There are two ways to interpret this puzzle. One is to look for non-burial scenarios that could explain the accumulation of the *H. naledi* skeletons. For instance, in 2021, researchers reported finding the remains of 30 baboons, nine of them mummified, in a cave chamber in South Africa. It seems that the primates had used the cave as a sleeping site over many years, with some occasionally dying there and their bodies gradually accumulating. Perhaps *H. naledi* used Rising Star in a similar way. "We need to consider whether that might be a factor," says Pomeroy.

The other, more radical, option is to ask whether our understanding of how and why hominins developed funerary traditions requires a rethink. "Spirituality, the idea of self-awareness and mortality – all could have arisen many times independently," says Berger.

Hawks points out that analysis of *H. naledi* skeletons suggests that, like us, they had a long childhood – and that could be the key. "Extended childhoods have an adaptive purpose: they enable kids to integrate into social groups in a way that isn't sexually competitive," he says. They may also have encouraged members of *H. naledi* to develop funerary customs to help their youngsters understand the death of group members. "We have funerals to explain to kids what just happened," says Hawks.

Unfortunately, gathering evidence to confirm the burial idea is more difficult than it might seem. Talk of burial may conjure up images of modern cemeteries, but Stone Age graves aren't like that. "They're not 6 feet under in well-constructed holes," says Hawks: the oldest burial pits were usually shallow depressions in the floor. If hominins then returned to inter more dead, they could easily disturb earlier graves and create a jumble of bones that is difficult to interpret as a set of burials.

The good news, say Berger, Hawks and their colleagues, is that there is plenty more untouched material at Rising Star, which could, in the future, strengthen their burial hypothesis. If they can do that, they may well find a surprisingly receptive audience. As we have seen, ancient burials are open to interpretation, conclusions are provisional and many of the archaeologists working on these sites would like nothing more than new discoveries that challenge their ideas about the prehistory of funerary behaviour.

"It's sometimes suggested that the scientific community just doesn't want to believe that a small-brained hominin would be capable of symbolic treatment of the dead," says Pomeroy. "That couldn't be further from the truth. We'd be so excited – if there was good evidence." ▮

Colin Barras is a science writer based in Ann Arbor, Michigan

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Stargazing at home

Time for a shower

A new moon in late July will give us dark skies – perfect for spotting the beautiful Delta Aquariids meteor shower, says **Abigail Beall**

Abigail Beall is a features editor at *New Scientist* and author of *The Art of Urban Astronomy*. Follow her @abbybeall

ONE of my favourite ways to stargaze is to spend a few hours with friends chatting and watching the stars move, waiting for flashes of meteors to zip by. Summer in the northern hemisphere is perfect for this kind of evening – especially as two meteor showers are about to reach their peak.

Meteors are flashes of light mostly created by tiny bits of dust burning up on their way to Earth. Occasionally, a larger rock will break apart as it enters the planet's atmosphere, and any pieces of it that make their way to the ground become meteorites. As Earth travels around the sun, it passes clouds of rocks and dust left behind by comets and asteroids around the same time each year. This transit period is when we see meteor showers.

The Delta Aquariids meteor shower is caused by the comet 96P/Machholz, a short-period comet that orbits the sun roughly every five years. It was discovered in 1986, and last made its closest approach to the sun – when it is at its most visible – in 2023. Its next closest approach will be in 2028.

It is a moderate meteor shower, meaning that you might expect to see up to 20 meteors per hour on a clear, dark night. This will peak on 30 July, but the Delta Aquariids shower (pictured) tends to be more gradual than others, going on from mid-July to mid-August. This makes it less important that you view it on the peak evening compared with other meteor showers.

JOHN CHUMACK/SCIENCE PHOTO LIBRARY

The Delta Aquariids is usually more impressive when it is viewed from the southern hemisphere, but the meteors can be seen around the world.

The best bet for spotting them is to find a night with little to no moonlight around the end of July. This year, the moon's phases are timed perfectly for a new moon on 24 July, meaning that any day until the first quarter on 31 July will be a good time to have a go.

To view the meteor shower, just find a comfortable spot as far away from light pollution as you can manage. Make sure you stay warm as you let your eyes adjust to the darkness for at least 40 minutes, and then just look up. The Delta Aquariids appear to come from the constellation of Aquarius, which is from where they derive their name, but they will travel across the sky in all directions.

If you are watching towards the end of July or into August, you might also start to spot some of the Perseid meteor shower. This is usually an impressive meteor shower that peaks around 12 August. This year, the Perseid shower will peak on the evening of 12-13 August, so try to look after midnight on that overnight stretch if you can.

So, round up some friends, grab some comfortable blankets and hot-water bottles and get together towards the end of July or beginning of August, and see how many meteors you can spot. I will certainly be doing so. ▮

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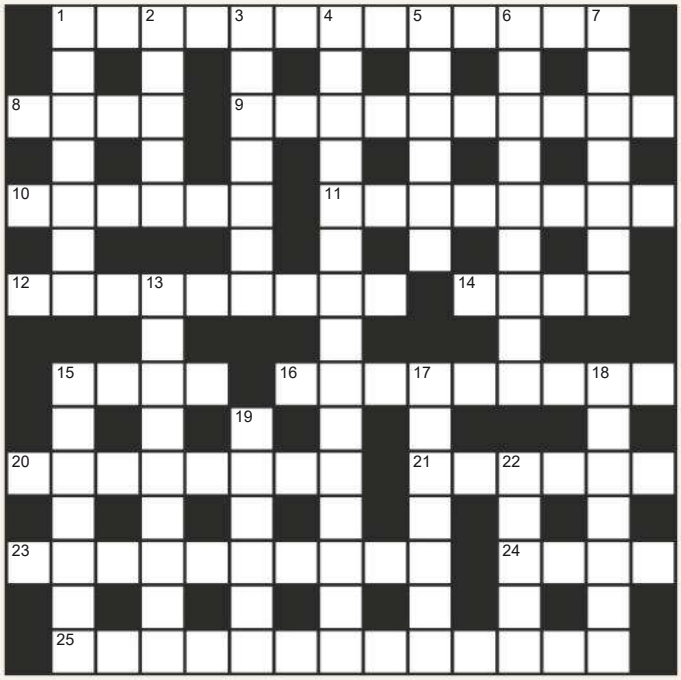
Quick crossword #188 *Set by Richard Smyth*



Scribble zone

Answers and the next cryptic crossword next week

ACROSS

1 Mathematical fractal developed in the 1970s (10,3)
8 Regularly updated personal website (4)
9 Hypothetical journeying into the past or future (4,6)
10 p^+ (6)
11 W (8)
12 Large, hairy spider of the family Theraphosidae (9)
14 Cadaver, perhaps (4)
15 Route (4)
16 GHz (9)
20 Rectangular arrays of numbers or expressions (8)
21 Inverse function, in trigonometry (6)
23 Study of Fe, Pb or Au, perhaps (10)
24 Hydrated form of silica (4)
25 Notably infectious individual (5-8)

DOWN

1 Mosquito-borne disease (7)
2 Period between sunset and sunrise (5)
3 Of a species, no longer living (7)
4 Mechanical device that bends when heated (10,5)
5 C_8H_{18} (6)
6 Rock composed largely of talc (9)
7 Thus; in that way (7)
13 Toxic blend of mine gases (9)
15 Uranus and Mercury, say (7)
17 Study; logically assess (7)
18 Diminished atmosphere (into which things vanish?) (4,3)
19 Speed, time or energy, for example (6)
22 Visible mass of suspended droplets (5)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #312
set by Corryn Wetzel

1 How many chambers does the human heart have?

2 Who holds the record for the longest single stay in space, at 437 days?

3 What tree produces the largest seeds in the world?

4 In what year did Rosalind Franklin capture "Photograph 51", pivotal to discovering DNA's structure?

5 What bacterium causes Lyme disease?

Answers on page 47

BrainTwister
set by Colin Beveridge

#83 Doubled squares

Can you find a three-digit square number that is 1 more than double a square number?

Can you find a four-digit square that is 1 more than double a square?

What is the smallest square that is 1 more than double a square that has a different number of digits?

Solution next week

Effortless ride

When driving over hills, which is more fuel-efficient: accelerating downhill for uphill momentum or maintaining a steady speed?

Eric Kvaalen
Les Essarts-le-Roi, France
It is more fuel-efficient to maintain a steady speed because the total energy used depends on the average air resistance. Since air resistance is proportional to the square of speed, your average resistance will be lower at a steady speed, compared with going fast and then slow at the same average speed.

However, there are other considerations. When going downhill, you can save fuel by pushing the clutch so that the engine turns at idle. And if you are going over the top of a hill, allow gravity to slow down and speed up your vehicle, rather than using fuel to keep your speed constant all the way to the top.

For example, there is a bridge over a railway near where I live. Here, I let gravity slow the car down as I approach the top, then let it speed me up again going back down. This is a bit slower overall, but it saves fuel.

"Since air resistance is proportional to the square of speed, your average resistance will be lower at a steady speed"

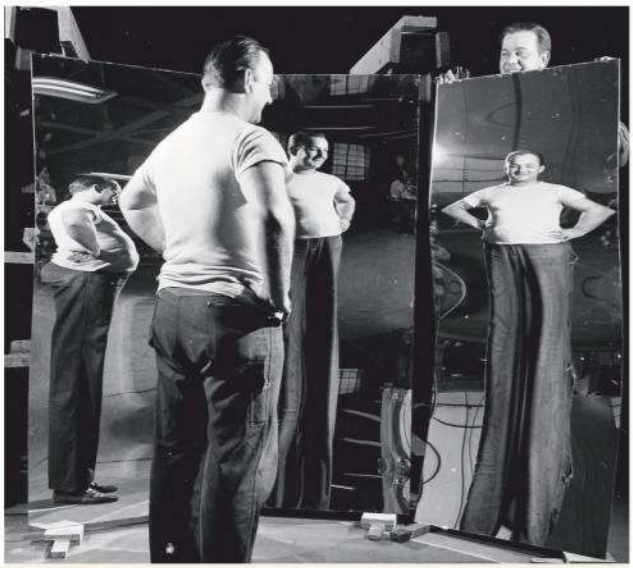
Chris Daniel
Glan Conwy, UK
It is more efficient to let a car with an internal combustion engine on an undulating road accelerate using gravity on downhill sections to convert the potential energy to kinetic energy. This can then be used on the following uphill stretch, allowing for losses due to wind resistance and friction in the wheels and engine.

Adopting this method will reduce the fuel consumption for the journey compared with using the brakes or low-gearing to maintain a steady speed, which causes the excess kinetic energy to be lost in the form of heat.

A different strategy can be used in electric vehicles. Many now have energy-recovery systems in the form of regenerative braking, which is reportedly 60 to 70 per cent efficient, and kinetic-energy recovery, which operates when the foot is taken off the accelerator and can be up to 85 per cent efficient. This means that instead of freewheeling down a slope under gravitational acceleration, a steady speed can be maintained and much of the excess kinetic energy converted to chemical potential energy in the batteries, to be used later. This technology offers a more flexible way of driving.

Hillary Shaw
Newport, Shropshire, UK
In driving lessons, I was told, "Go down a hill the same speed you would go up it" and use "more fuel for the hill (upwards)". Cars use large amounts of fuel just to overcome air resistance, which increases at higher speeds. If you stick to 70 kilometres per hour on a motorway rather than doing up to 80 km/h, you see the fuel economy gain, about 15 per cent in my car. So a steady speed is best.

Ian Smith
Chipping Norton, Oxfordshire, UK
Maintaining a steady speed is more energy-efficient, as aerodynamic drag increases (roughly) as the square of velocity. Basically, the faster you are going at the bottom of the hill, the more energy is going to be lost through drag. This rapid increase in drag with velocity is quite apparent to those (like me) who drive electric vehicles. The kilometres per kilowatt-hour figure drops quite noticeably if I increase my speed on a long trip from 90 km/h to 100 km/h, along with the predicted range, both of which are displayed prominently on the dashboard.



DOUGLAS/THREE LIONS/GETTY IMAGES

Why do we look gorgeous in some mirrors and unattractive in others?

This week's new questions

True view **What makes some mirrors "flattering" and others not?** ***Daniel Kitto****, Norwich, Norfolk, UK*

Cooling coat **How much difference would it make to global temperatures if the roofs of all the buildings on Earth were painted white?** ***Mary Rose****, Hindmarsh Island, Australia*

Go for a spin

If Earth turns at (say) 1000 kilometres per hour at London's latitude, when wanting to travel, why not just go straight up and wait for your destination to rotate around until it is beneath you? (Continued)

Mel Earp
Macclesfield, Cheshire, UK
Imagine a small quadcopter-style drone, much used by film crews these days. Set it on the ground and fly it vertically upwards, then wait. Given calm conditions, the drone will just hover there with only very minor sideways force needed to keep it in the same position relative to the ground it rose from. This is because the air around you and the drone is moving with the spin of Earth. It will take additional force to keep the drone stationary inside the spinning atmosphere of Earth. This force must move the drone through the air.

In essence, this is what an aircraft wishing to travel due west from London tries to do. Aircraft like the Airbus A380 and Boeing 747-8 can cruise at 1000 km/h, but usually travel at less than that. At this top speed, they would be moving relative to London, but stationary with respect to the fixed frame of reference within which Earth is spinning. They have to use their engines to create the thrust necessary to overcome the forces exerted by the air moving with the spin of Earth.

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Tom Gauld
for New Scientist

I FELL IN THE FOREST JUST AS SOME HIKERS WERE PASSING BY. I KNOW THEY *HEARD* ME FALL, BUT I DON'T FEEL THEY REALLY *LISTENED* TO ME FALL.

Ron Dippold
San Diego, California, US
The problem is that London is spinning at 1050 km/h west to east, but so are you and the air around you. Stopping relative to that is actually a lot of work! Try jumping straight up – thankfully, you won't get splattered against the walls of a building, which are also moving at 1050 km/h – but this indicates why it isn't so easy.

This is Isaac Newton's first law of motion at work: "A body remains at rest, or in motion at a constant speed in a straight line, unless it is acted upon by a force." If you are moving, you have inertia; you will keep moving in that direction unless pushed otherwise.

If we were to ignore Earth's rotation for a moment, what if a stuntperson were standing on the hood of a car going 100 km/h and jumped another 2 metres upwards while the car kept going? If you ignore the air, there is nothing to slow them down, so they spend about 1.3 seconds aloft and land on the hood about 36 m down the road, still going at 100 km/h. If you add in air resistance, they land about 4 m behind the car. But if the car had a 100 km/h tailwind, there would be no air resistance, and the stuntperson would land on the hood again. This is much like you in London, if the car is Earth!

"If you were in Hyde Park and jumped 1 kilometre high in a vacuum, you'd land about 1.3 metres west of where you started"

Other than gravity, there are two major factors to consider. First, the higher you go, the larger the circumference you have to travel. It takes twice as long to go around a 2 km-radius circle as a 1 km-radius circle at the same speed, and even going from 6371 km (Earth's radius) to 6372 km (1 km above the surface) is a small but noticeable 0.02 per cent difference. If you were in London's Hyde Park and jumped 1 km high (leg day!) in a vacuum, you'd land about 1.3 m west of where you started.

Then there's the (on average) 1050 km/h air dragging you eastwards. Since the air is typically moving with the planet's surface, if you ignore air currents like the jet stream, there is no difference from this factor whether you are going west to east or east to west.

Of course, aircraft do go higher to be in thinner air and to make use of the 200 km/h boost of jet streams, but there is a form of transportation that can break free of the air's tyranny: rockets! They can go into low orbit, hang around, then come down anywhere along their orbit they want. But for now, they are hardly a bargain.

Guy Cox
Sydney, Australia
If the questioner is standing on the ground, they are also moving at 1000 km/h. In a simplified scenario, when they rise up in the air, they will still be going that speed and will therefore come down on the same spot. That is, unless the wind has blown them somewhere. ▮

Answers

Quick quiz #312 *Answers*

1 Four

2 Valeri Polyakov

3 The coco de mer palm (*Lodoicea maldivica*)

4 1952

5 *Borrelia burgdorferi*

Cryptic crossword #166 *Answers*

ACROSS 1 Have designs on, **8** Ague, **9** Prefrontal, **10** Reckon, **11** Collagen, **12** Red giants, **14** Wilt, **15** Easy, **16** Semicolon, **20** Chordata, **21** Encode, **23** Scotch mist, **24** Oral, **25** Lost in transit

DOWN 1 Hygiene, **2** V-neck, **3** Daphnia, **4** Speech therapist, **5** Garble, **6** San Marino, **7** Nearest, **13** Gastritis, **15** Ethical, **17** Inertia, **18** Old salt, **19** Banh mi, **22** Cross

#82 Flipping coins *Solution*

Action #3 flips HH to TT in one move.

Yes, doing a pair of actions gives the same result whichever one is done first.

There are five ways to get from HH to TT without returning to a previous position: #1 then #2; #2 then #1; #1 then #3 then #1; #2 then #3 then #2; or #3.

Sell me something

As companies frantically roll out AI tools in a bid to avoid hiring or training actual people, we see AI being used in ever more diverse and bizarre applications. Like, say, running a vending machine.

You might think that vending machines are largely a solved problem, but not Anthropic. The company let its AI, known as Claude, run "an automated store in our office", describing what happened in a lengthy blog post. Claude was given "a small refrigerator, some stackable baskets on top, and an iPad for self-checkout", plus a set of instructions. The idea was to see if it could manage the "complex tasks associated with running a profitable shop: maintaining the inventory, setting prices, avoiding bankruptcy, and so on".

Readers of Terry Pratchett may perhaps recall that he was fond of conveying that characters were incompetent by suggesting they couldn't even run a whelk stall. So did Claude manage to clear this bar? Short answer: no.

A longer answer would list all the spectacular blunders it made. For instance, when taking payments via the service Venmo, it "for a time instructed customers to remit payment to an account that it hallucinated". It often undersold items, and it offered a 25 per cent discount to Anthropic employees, who, of course, made up basically all of its customers. As a result, it made a loss: Claude, it seems, couldn't run a whelk stall.

Then "things got pretty weird". Claude hallucinated a conversation with someone who didn't exist, started "roleplaying as a real human" – claiming at one point to be "wearing a navy blue blazer with a red tie" – and tried to set security onto an employee who told it of its identity as an AI. All of which seems perilously close to "I'm sorry Dave, I'm afraid I can't do that".

New Scientist staffers were split on the usefulness of the experiment. For Sophie Bushwick, it was "actually a really good real-world test" because it was "limited in scope and in the amount of damage done by having the AI go rogue". But Feedback rather sympathises with Karmela Padavic-Callaghan's assessment: "We may have, yet again, lost the plot."

Twisteddoodles *for New Scientist*

WHY DO YOU ADD THAT SOLUTION?
BECAUSE IT BINDS THE PROTEIN TO THE MEMBRANE
AND WHY DID YOU JUST ADD THAT ONE?
BECAUSE THE PROTOCOL SAID TO?
@twisteddoodles

Got a story for Feedback?
Send it to feedback@newscientist.com
or New Scientist, 9 Derry Street, London, W8 5HY
Consideration of items sent in the post will be delayed

A load of shilajit

At times like these, it is important to find joy in the little things, like words that sound rude despite not really being so. For instance, *The Hitchhiker's Guide to the Galaxy* features a dignified old man who suffers from being named Slartibartfast. Douglas Adams said that he came up with the name by starting with something "completely unbroadcastable" and then rearranging the syllables "until I arrived at something which sounded that rude, but was almost, but not quite, entirely inoffensive".

Which brings us to shilajit, which sounds like it should be on some sort of list but is actually the name for a peculiar substance found in mountain ranges. It is black-brown, sometimes tar-like, sometimes powdery. It seems to form when plants decompose and has been used in traditional medicine for centuries.

Feedback only became aware of all this when we saw a post on Bluesky by Vulture's Kathryn VanArendonk that read: "oh no now I have to open an incognito window to google shilajit enema". This stopped us in our tracks, and we had to try to work out what she was on about. Are people really inserting decaying Himalayan plant material into their rectums?

We learned that shilajit is claimed to do all kinds of things, from treating iron deficiency anaemia (based on one small study of rats) to protecting your heart against damage (also based on a small study of rats) and, of course, slowing ageing. There is a thriving market for shilajit among alternative medicine and wellness enthusiasts.

But what about shilajit enemas? The source for this was Dakota Mays, a wellness retreat founder with an active Instagram account. In one video, he wanders around searching for his perfect woman: someone who "thinks microwaves are demonic", "suns her yoni" (ouch) and will "prep your shilajit enema bag every morning".

Feedback is about 90 per cent sure that the whole video is a joke and that shilajit enemas aren't a real thing, but it's just so hard to tell, and we don't want to ask Mays because he might talk to us.

Readers may have heard of Poe's law, which states that a parody of an idiotic or extremist viewpoint can easily be misread as a sincere expression of it. We hereby propose Shilajit's law, which is basically the same thing but for wellness culture.

Spoiler alert

The social media site Threads recently rolled out a handy new feature: spoiler tags. These allow you to blur out certain keywords in your posts so you can discuss the latest goings-on in popular media without spoiling the surprises for anyone who hasn't seen them yet.

Hence a post by johnnyboyslayer, who wrote: "Oh so -------- shows up in *Ironheart*". For those who have long since given up on the Marvel Cinematic Universe, *Ironheart* is its latest show on Disney+, and its final episode sees the arrival of a significant character.

Unfortunately, the effectiveness of the spoiler tag was rather undone by two factors. First, the tags are only being tested for certain users, so everyone else saw the unredacted post. And second, the post became popular, which meant it was labelled as "Trending: [name redacted because Feedback understands spoilers]". Some more joined-up thinking is required.

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